Deep Inelastic and Deep Exclusive Results from Jefferson Lab

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Deep Inelastic Scattering 2011
Newport News, Virginia
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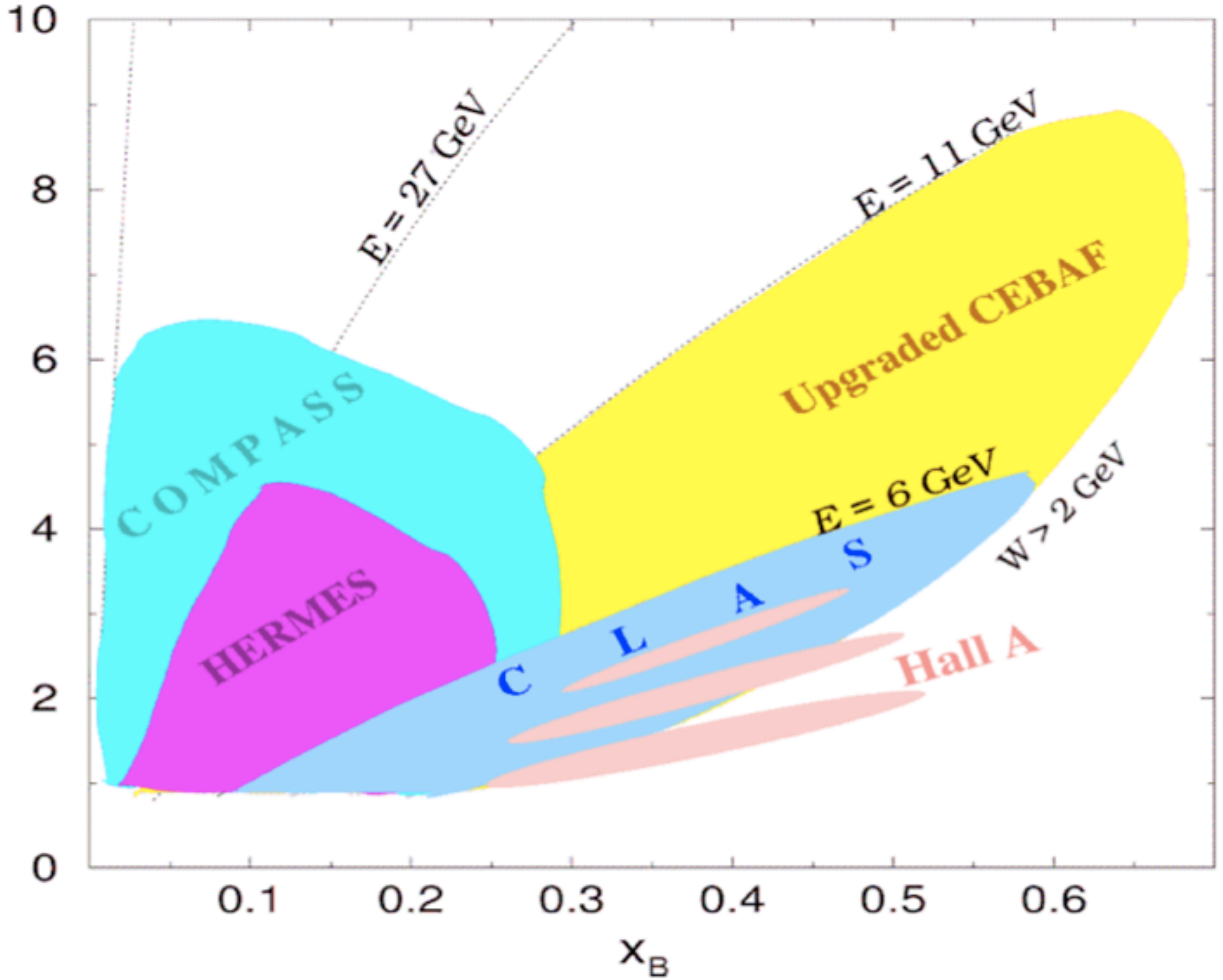
Introduction

- The only thing we can measure is a cross section.
- But by separating kinematics from nucleon structure, we can identify robust, experimentally determined objects, the structure functions:

$$\frac{d\sigma}{dx\,dy\,d\psi} = \frac{2\alpha^2}{xyQ^2}\frac{y^2}{2(1-\varepsilon)}\Big\{\boxed{F_T} + \varepsilon\boxed{F_L} + S_\parallel \lambda_e \sqrt{1-\varepsilon^2}\,2x\boxed{(g_1-\gamma^2 g_2)}$$
$$- |\boldsymbol{S}_\perp|\lambda_e\sqrt{2\varepsilon(1-\varepsilon)}\,\cos\phi_S\,2x\gamma\boxed{(g_1+g_2)}\Big\}$$

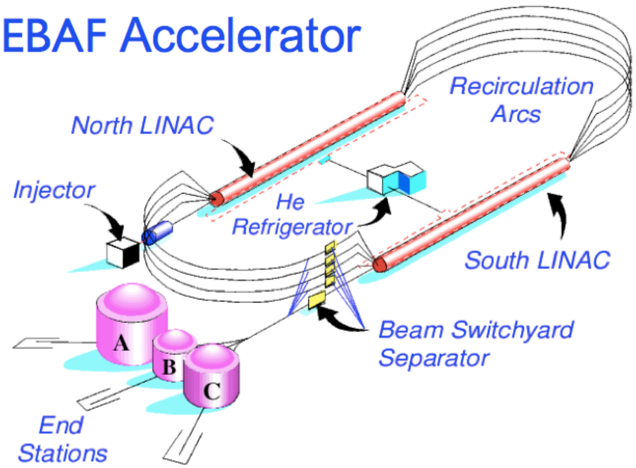
- Thus, F_T, F_L, g_1, $g_2(x,Q^2)$ can be extracted for all x, Q^2.
- Experiment tells us where these can be interpreted in terms of parton distribution functions in pQCD and where complications show up.
- PDFs are known only through model fitting of structure functions.
- More so for transverse momentum dependent distributions and generalized parton distributions

JLab Kinematic Coverage

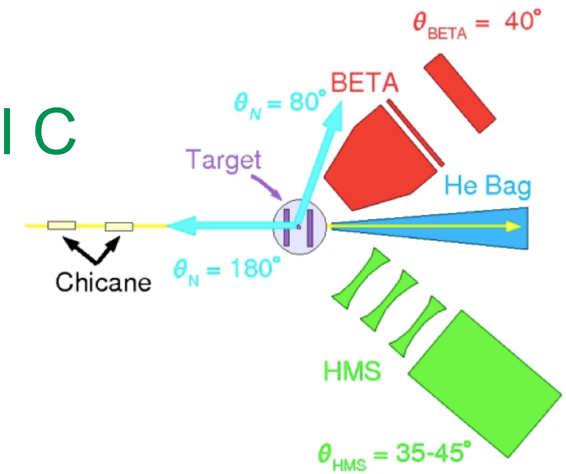


Jefferson Lab Halls

The CEBAF Accelerator

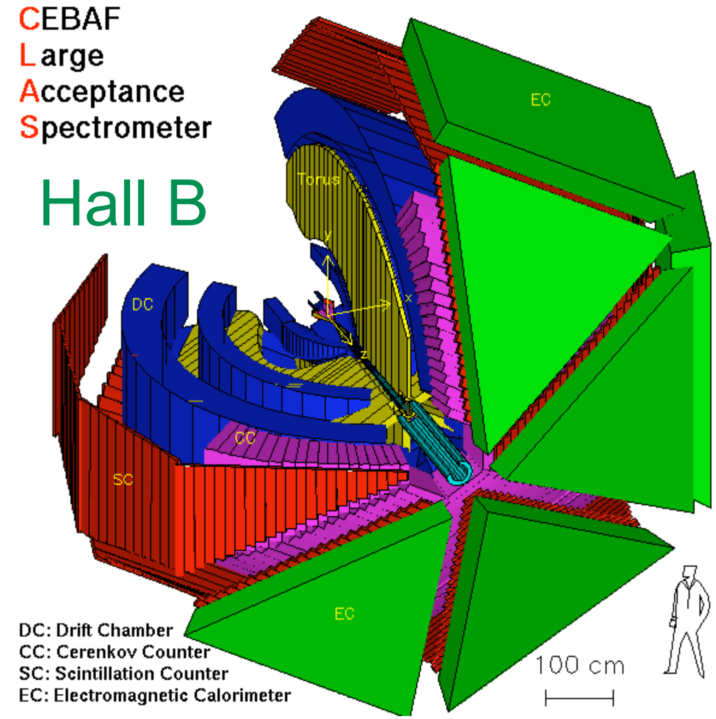


Hall C

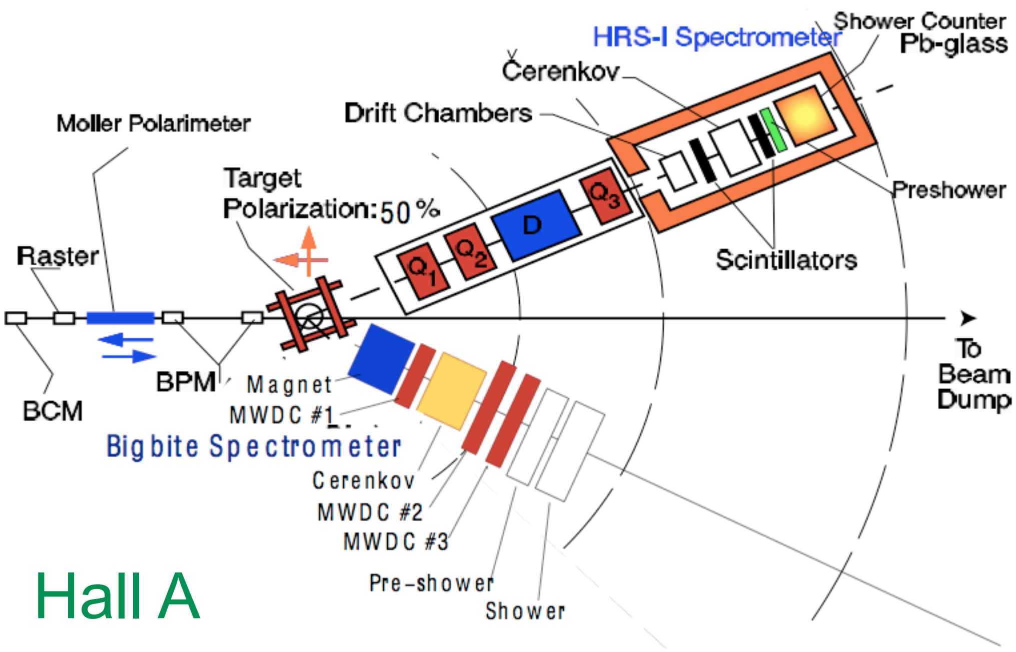


Hall B

CEBAF
Large
Acceptance
Spectrometer



Hall A



JLab Talks @ DIS2011

- ★**WG1PS2: Jeff Owens** ***Uncertainties in determining the d quark PDF at large values of x***
- ★**WG1PS2: Slava Tkachenko** ***Model independent extraction of neutron structure functions from deuterium data***
- ★**WG1PS7: Peter Monaghan** ***First Extraction of*** F_L ***Moments from World Data***
- ★**WG1PS7: Ibrahim Albayrak ...** ***Deuteron*** F_L ***... and Extractions of the Deuteron and Non-Singlet Moments***
- ★**WG1PS9: Silvia Pisano** ***Results and Achievements at CLAS***
- ★**WG1PS9: Simona Malace** ***Quark-hadron duality***
- ★**WG1PS10: Patricia Solvignon** ***The nuclear dependence of*** $R=\sigma_L/\sigma_T$ ***in Deep Inelastic Scattering***
- ★**WG2PSVM: Valery Kubarovsky** ***Vector-mesons production and DVCS at JLab***
- ★**WG4SINS: Hayk Hakobyan** ***Quark propagation and hadron formation in the nucleus***
- ★**WG4SINS: Sergio Anefalos Pereira** ***Strangeness production in CLAS***
- ★**WG6PSH1: Vincent Sulkosky** ***Neutron spin sum rules and spin polarizabilities at low*** Q^2
- ★**WG6PSH1: Hovhannes Baghdasaryan** ***Preliminary proton spin asymmetry results from SANE***
- ★**WG6PSH2: Nilanga Liyanage** ***Moments of the neutron*** g_2 ***structure function and ... higher-twist effects***
- ★**WG6PST2: Jin Huang** ***Measurement of double spin asymmetry*** A_{LT}
- ★**WG6PST3: Hamlet Mkrtchyan** ***The quark-parton model and low-energy factorization studies ...***
- ★**WG6PST3: Sucheta Jawalkar** ***Spin azimuthal asymmetries on longitudinally polarized proton***
- ★**WG6PST3: Wes Gohn** ***Beam single spin asymmetries in SIDIS from an unpolarized proton***
- ★**WG6PST4: Kalyan Allada** ***Single spin asymmetry results from neutron***
- ★**WG6PST4: Aram Kotzinian** ***SIDIS in target fragmentation region***
- ★**WG6PST4: Todd Averett** ***Target single spin asymmetry measurements***
- ★**WG6PSTV: Marco Mirazita** ***Lambda polarization in electroproduction at CLAS***
- ★**WG6PSHP1: Yohann Perrin** ***Coherent deeply virtual Compton scattering off helium (CLAS)***
- ★**WG6PSHP1: Andrey Kim** ***Studies of exclusive processes with a longitudinally polarized target***
- ★**WG7PS3:Dave Gaskell, Xin Qian, Yelena Prok, Javier Gomez, Francois-Xavier Girod, Gordon D. Cates** ***12 GeV***

Inclusive DIS

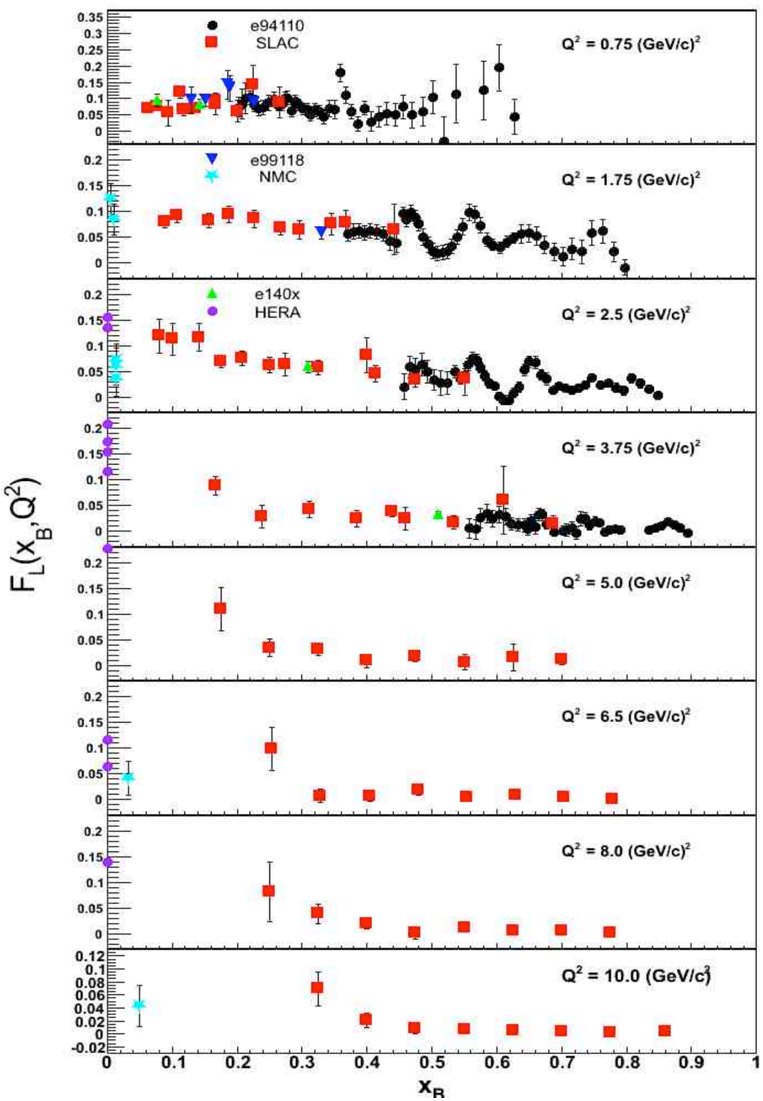
$$\frac{d\sigma}{dx\,dy\,d\psi} = \frac{2\alpha^2}{xyQ^2}\,\frac{y^2}{2\,(1-\varepsilon)}\,\Big\{\boxed{F_T} + \varepsilon\boxed{F_L} + S_\parallel \lambda_e\,\sqrt{1-\varepsilon^2}\;2x\boxed{(g_1 - \gamma^2 g_2)}$$

$$- |\boldsymbol{S}_\perp| \lambda_e\,\sqrt{2\,\varepsilon(1-\varepsilon)}\;\cos\phi_S\;2x\gamma\boxed{(g_1 + g_2)}\Big\}$$

Hall C Measurements of F_L

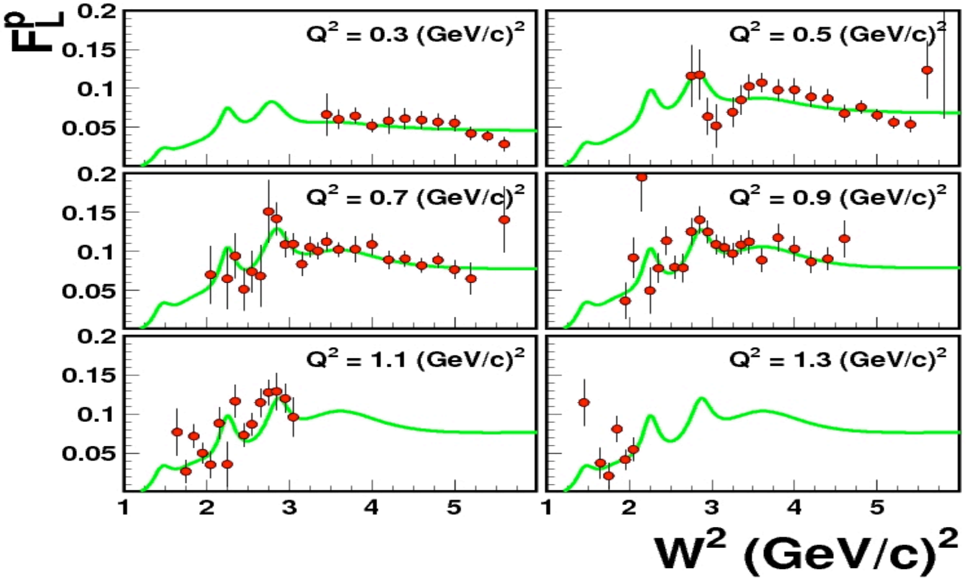
★**WG1PS7: Peter Monaghan** ***First Extraction of F_L Moments from World Data***

★**WG1PS7: Ibrahim Albayrak ...** ***Deuteron F_L ... and Extractions of the Deuteron and Non-Singlet Moments***



E04-110 proton

E00-002, Deuteron



- Rosenbluth separation of F_L and F_T
- Moments require data at all x, including the resonance region

Hall C Duality Averaging

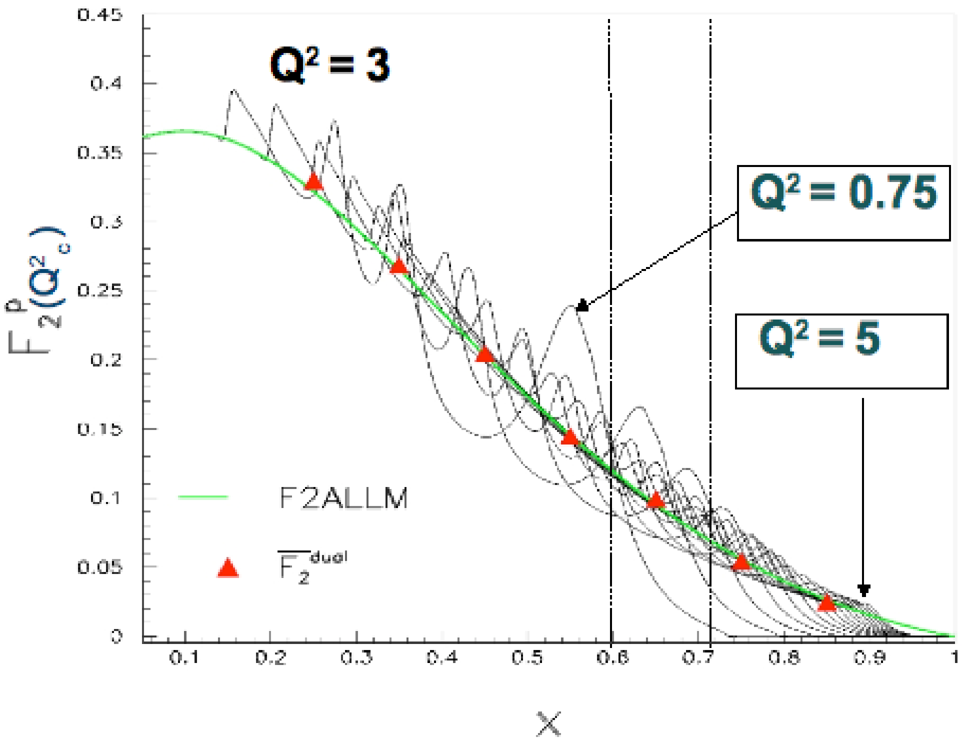
★**WG1PS9: Simona Malace *Quark-hadron duality***

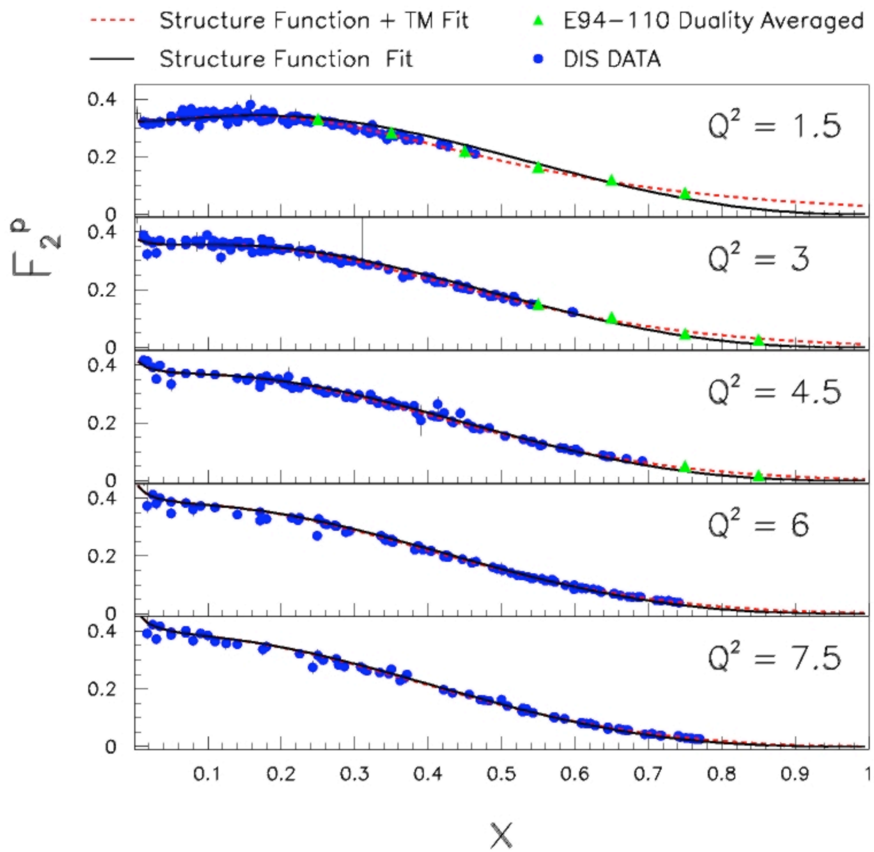
Hall C
Christy

$$F_2^{\mathrm{TMC}}(x,Q^2) = \frac{x^2}{\xi^2 r^3} F_2^{(0)}(\xi) + \frac{6M^2x^3}{Q^2 r^4} h_2(\xi) + \frac{12M^4x^4}{Q^4 r^5} g_2(\xi)$$

$$h_2(\xi,Q^2) = \int_\xi^1 du\, \frac{F_2^{(0)}(u,Q^2)}{u^2} \qquad \xi = \frac{2x}{1+\sqrt{1+4x^2M^2/Q^2}}$$

$$g_2(\xi,Q^2) = \int_\xi^1 du\; h_2(u,Q^2)$$





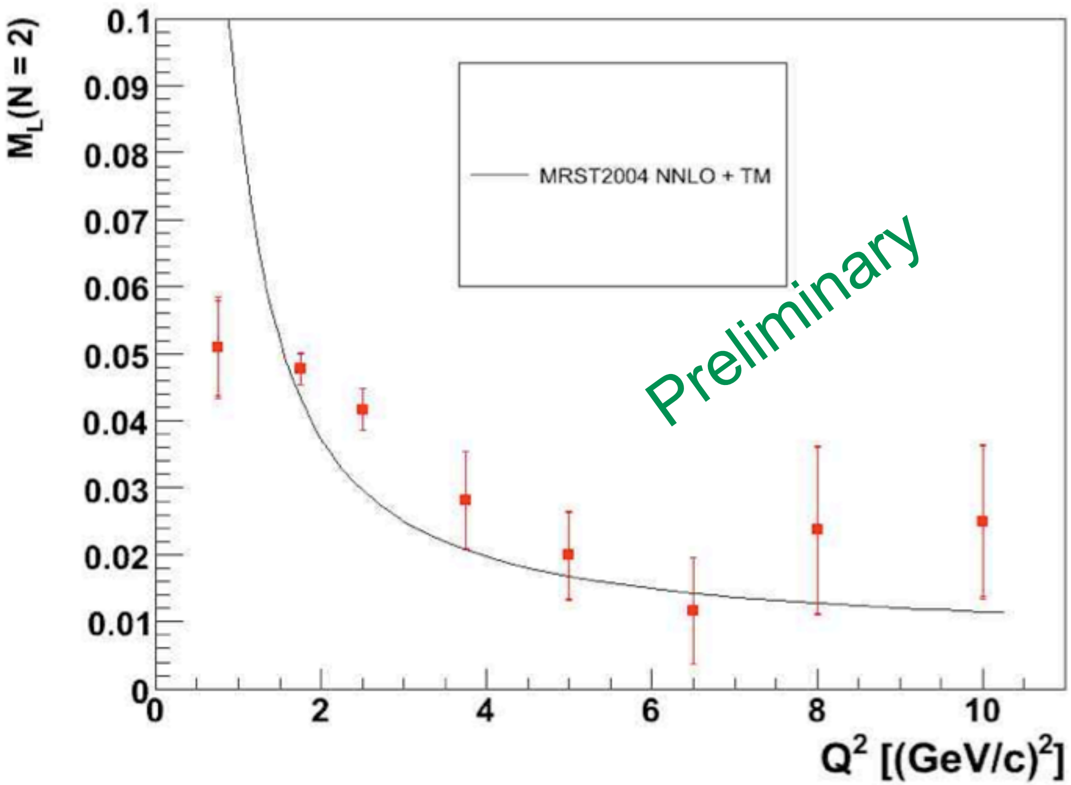
Hall C Moments of F_L

★**WG1PS7: Peter Monaghan** ***First Extraction of F_L Moments from World Data***

Cornwall-Norton Moments

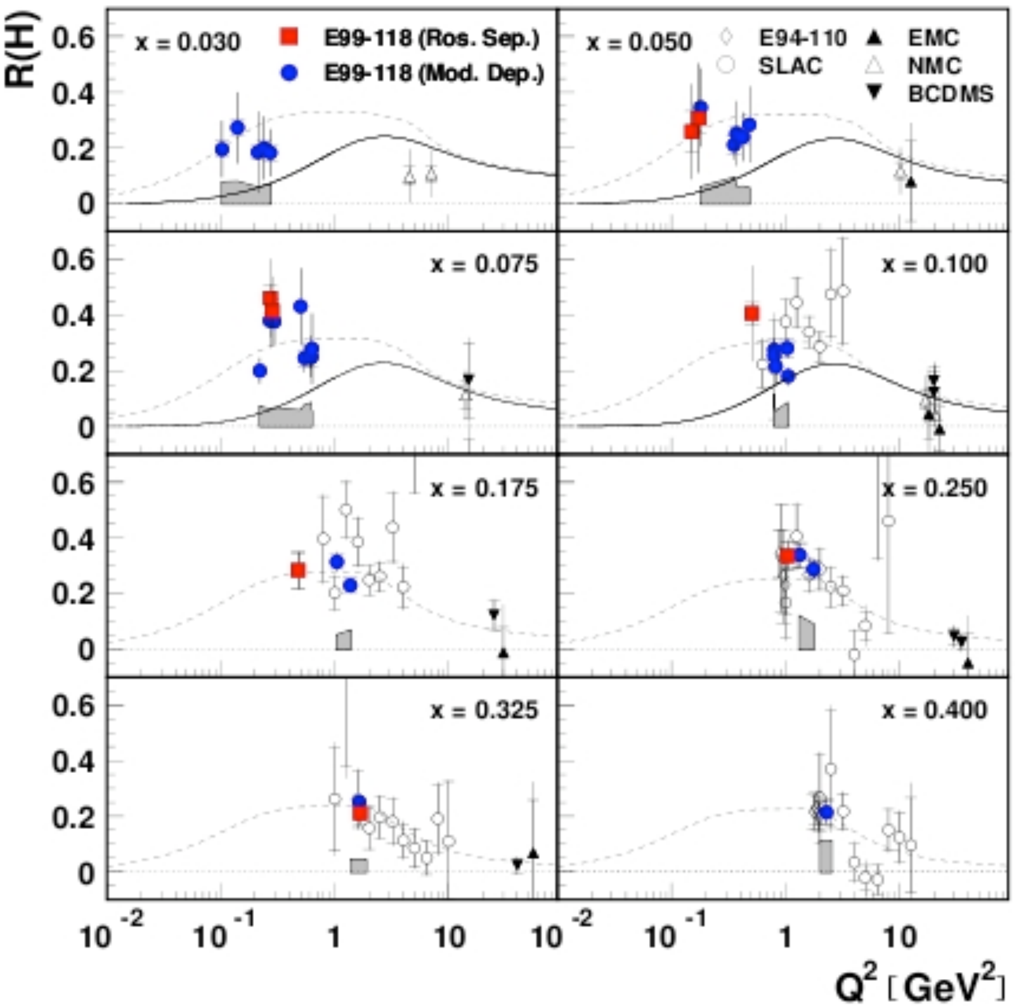
$$M_n^{2,L}(Q^2) \equiv \int_0^1 dx \;\; x^{n-2} \; F_{2,L}(x, Q^2)$$

Analysis of P. Monoghan, et. al



Hall C Determination of R

★WG1PS10: Patricia Solvignon *The nuclear dependence of R=σ_L/σ_T in Deep Inelastic Scattering*

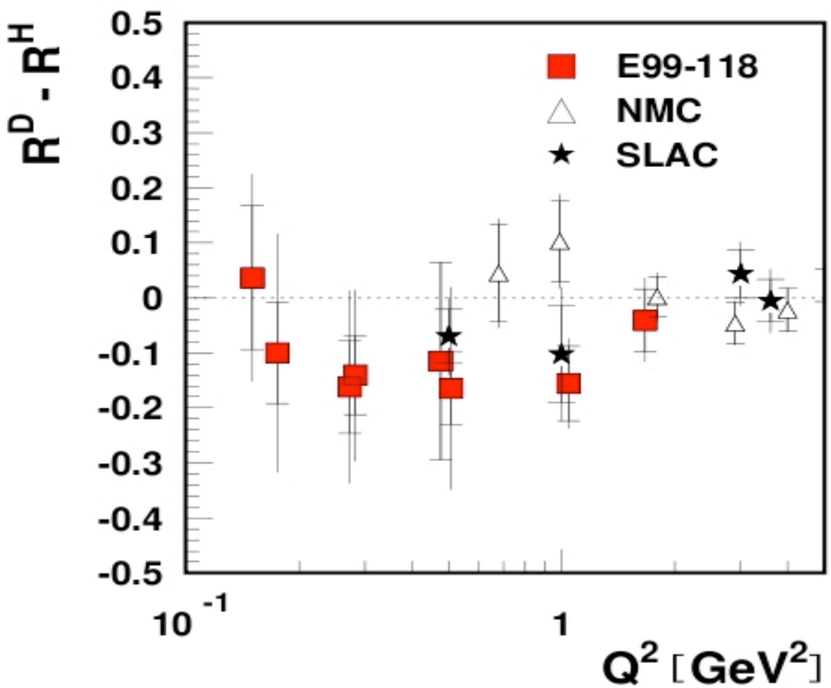


E99-118

p,d targets

Q^2=0.1-1.7 GeV^2

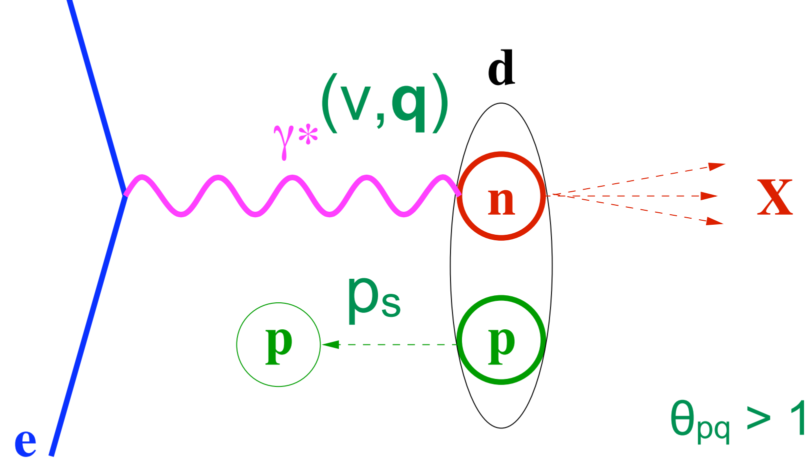
Measure of R=F_L/F_T



BoNuS: d(e,e'p_s)X

★WG1PS2: Slava Tkachenko *Model independent extraction of neutron structure functions from deuterium data*

Bound Nucleon Structure Experiment using CLAS



Detect the spectator proton from deuterium following *en* scattering. Make kinematic corrections using the spectator proton's energy E_s and momentum p_s.

$\theta_{pq} > 100^o$

$70 < p_s < 100$ MeV/c

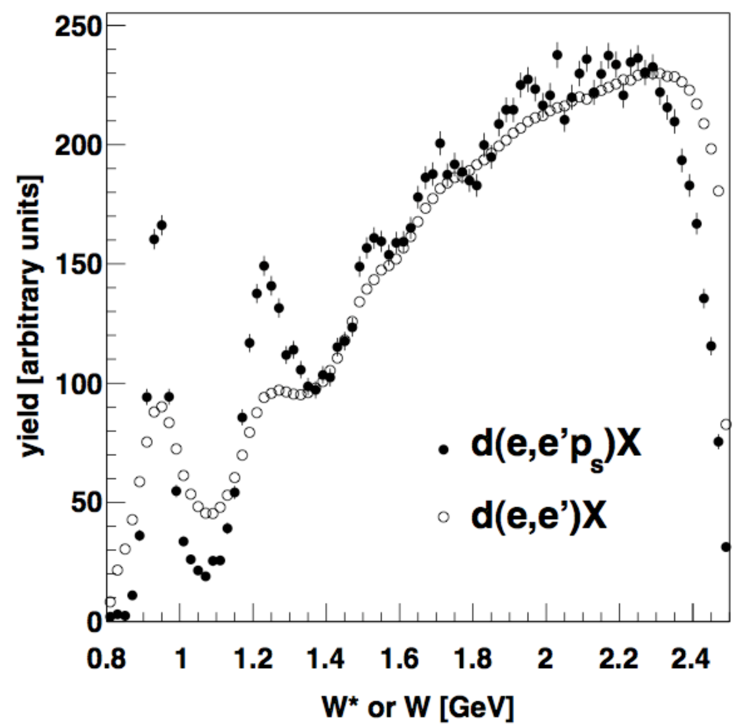
$E_{beam} = 4$ & 5 GeV

$$\alpha_s = \frac{E_s - p_{s_{||}}}{M_s}$$

$$M^{*2} = (M_d - E_s)^2 - \vec{p}_s^{\,2}$$

$$W^{*2} \approx M^{*2} - Q^2 + 2M\nu\,(2 - \alpha_s)$$

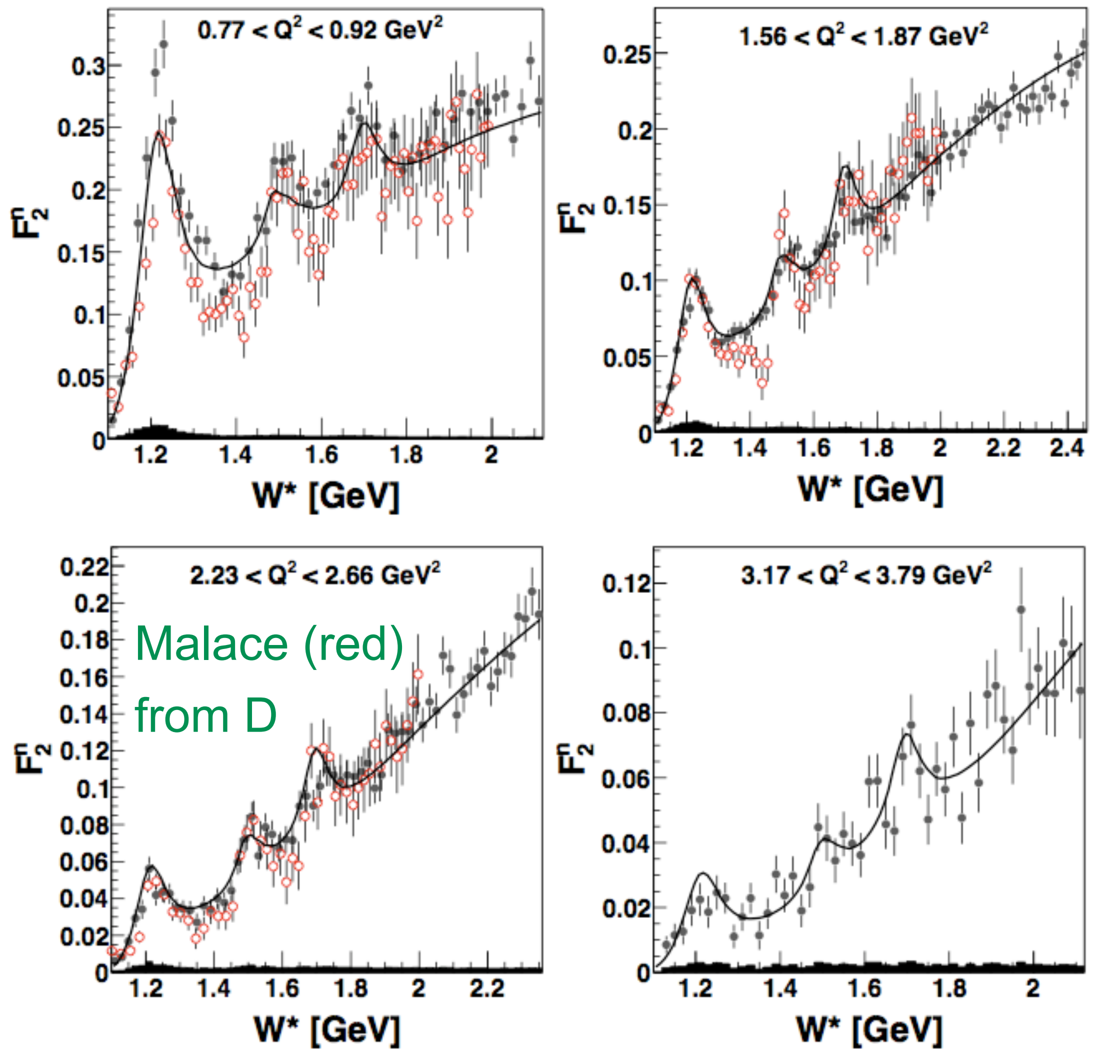
$$x^* = \frac{Q^2}{2p_N^\mu q^\mu} \approx \frac{Q^2}{2M\nu(2-\alpha_s)} = \frac{x}{2-\alpha_s}$$



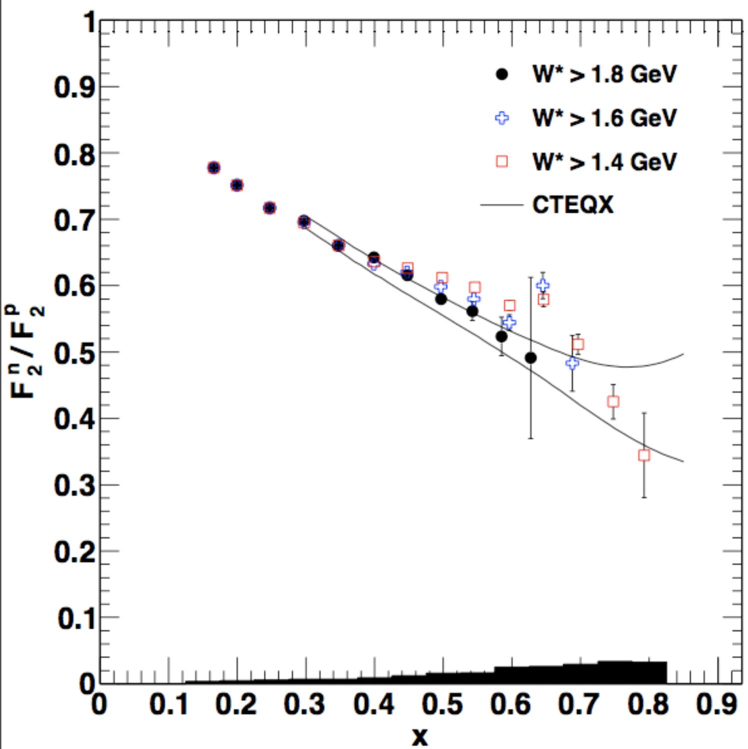
BoNuS Results for F_2^n

★**WG1PS2: Slava Tkachenko** ***Model independent extraction of neutron structure functions from deuterium data***

- First data from a 'free' neutron target
- Black line (right) is Bosted/ Christy model
- Black lines (below) are the CTEQX errors band



Malace (red) from D



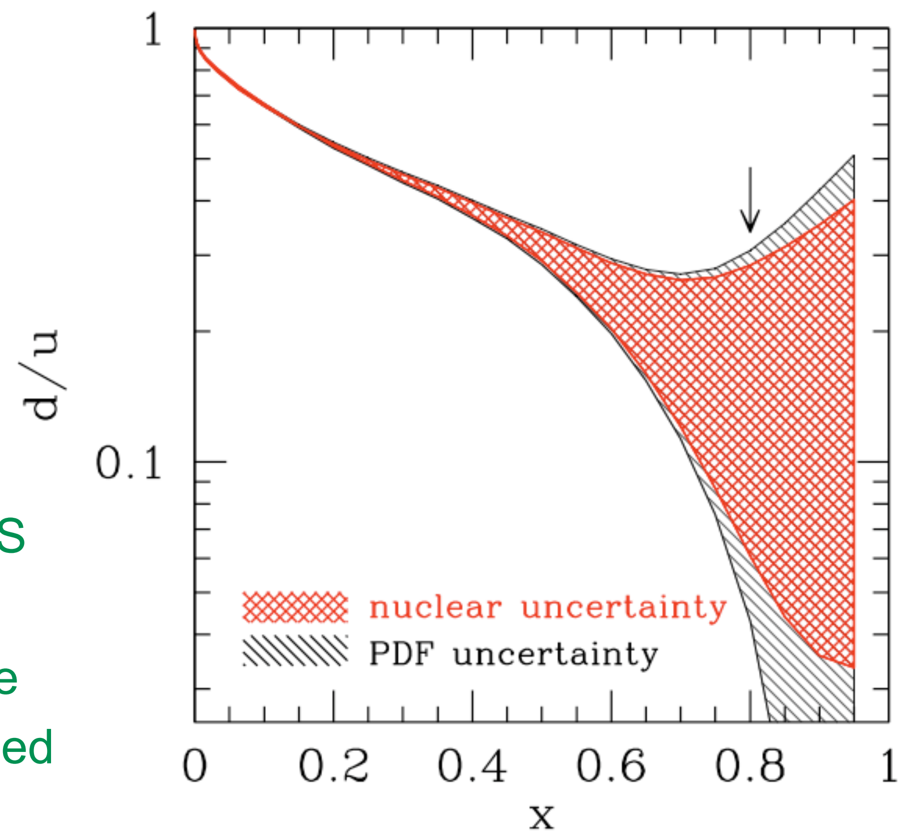
Global PDF fits at JLab

★**WG1PS2: Jeff Owens** ***Uncertainties in determining the d quark PDF at large values of x***

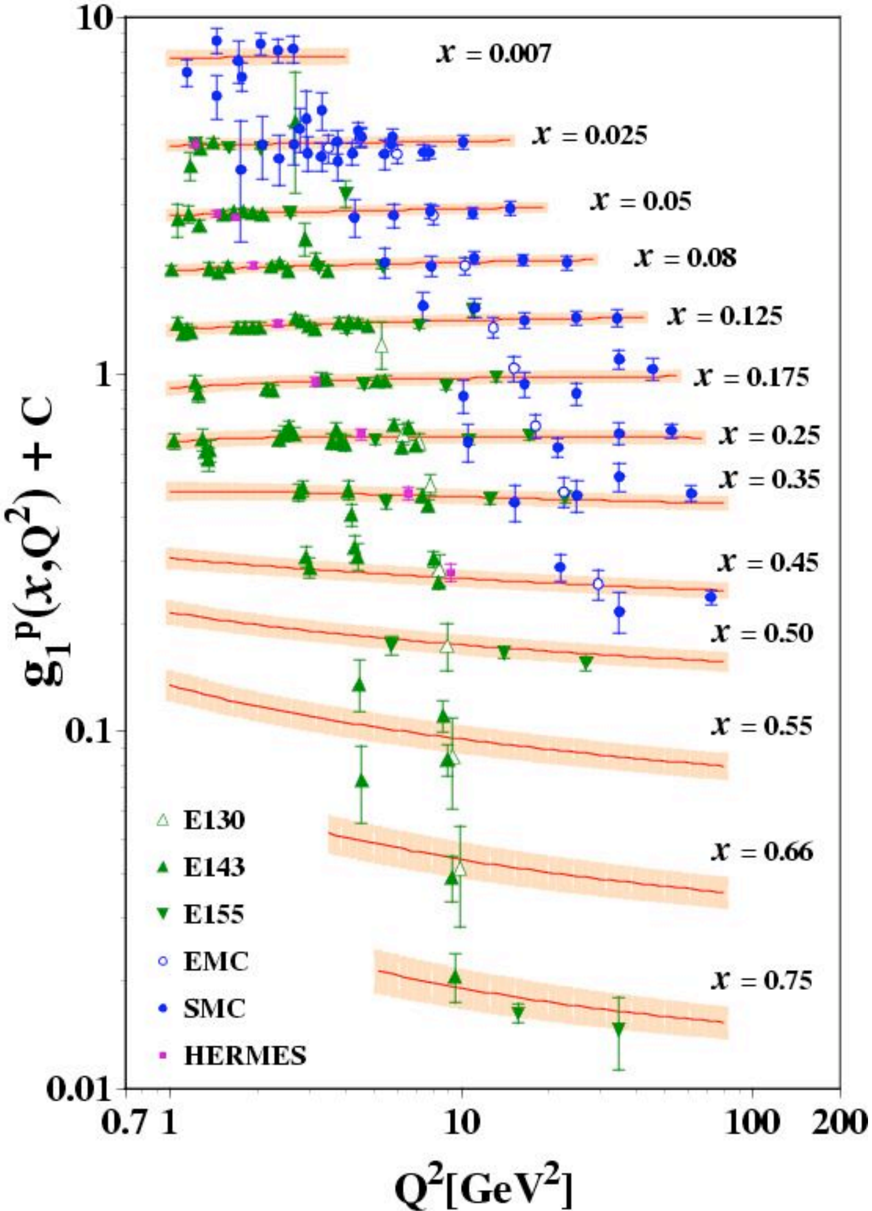
CTEQ-JLab (CJ) collaboration

Accardi, Christy, Keppel, Melnitchouk, Monaghan, Morfin, Owens, Zhu

- Focus on large-x, small-Q^2 region
  - fully exploit SLAC and JLab data
  - reduced PDF uncertainty at large x
- Flexible d-quark parametrization
  - extract d/u ratio at $x \to 1$
- Large nuclear uncertainty
  - d-quark (and gluons)!
  - need BONUS12, MARATHON, PV-DIS
- Polarized PDFs:
  - New JLab Theory/Experiment initiative
  - Use current & future data over extended x & Q^2 range

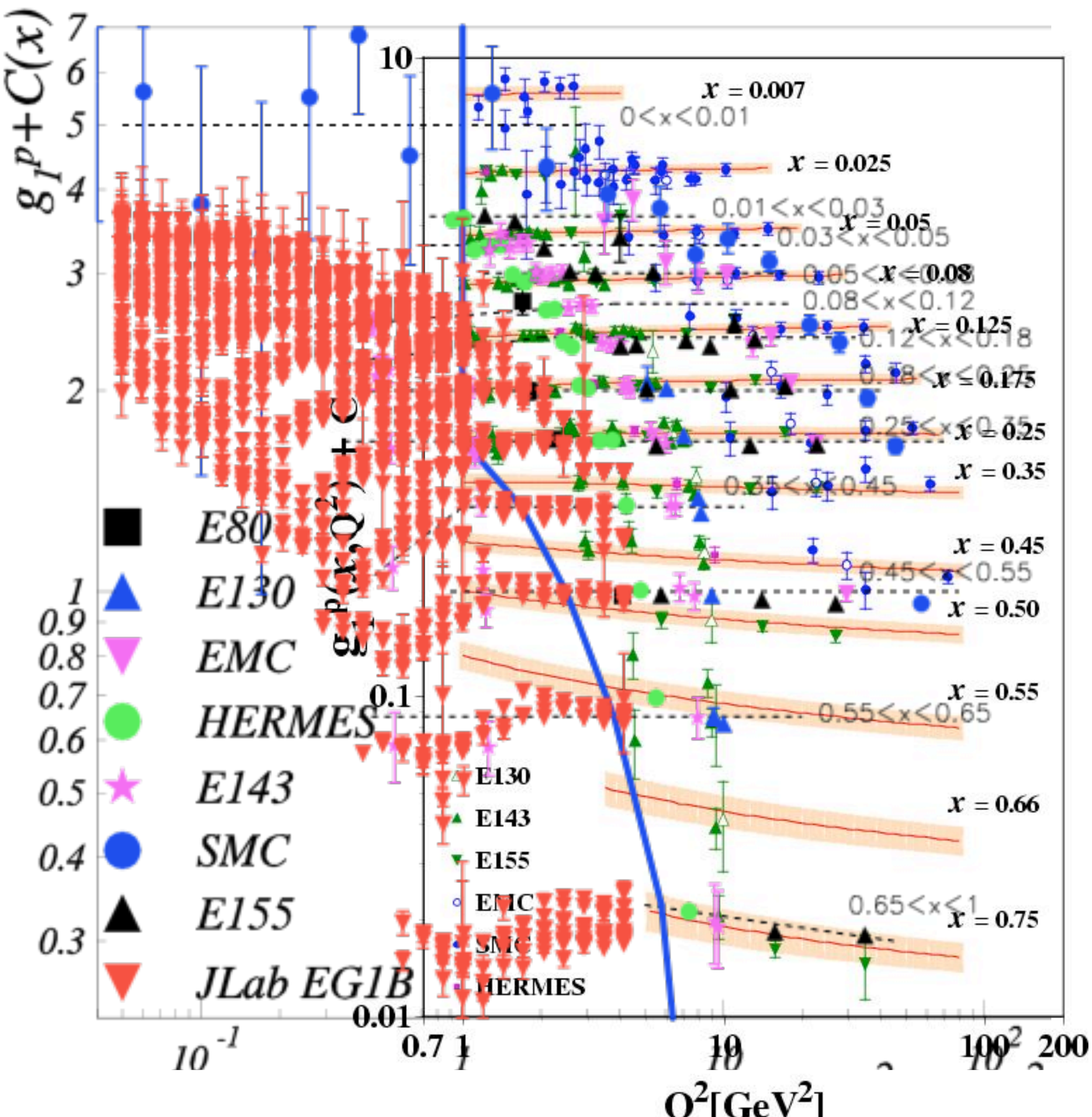


g_1 Data w/o CLAS



g1 Data w/ CLAS

★WG7PS3:Yelena Prok

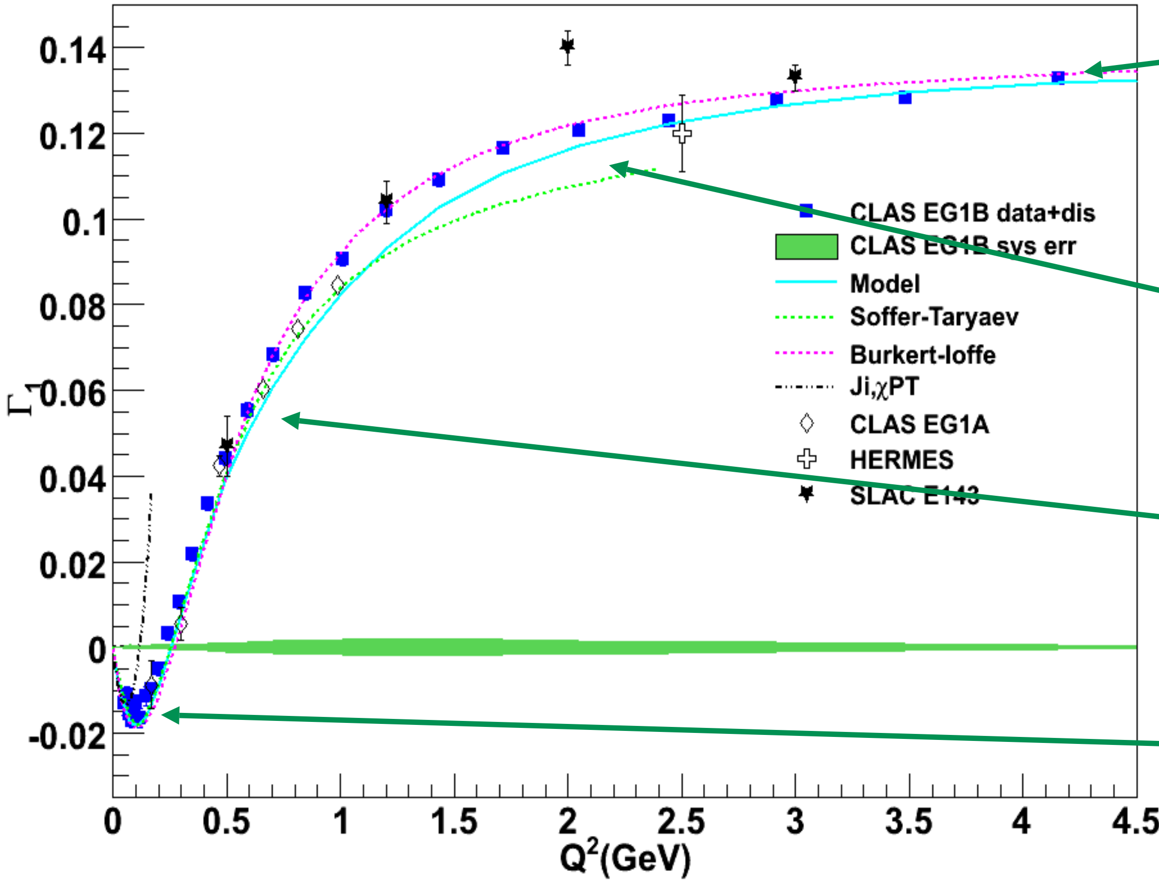


CLAS g_1 Moments

★WG7PS3:Yelena Prok

$\Gamma_1(P)$

$$\Gamma_1^{p,d}(Q^2) = \int_0^1 g_1^{p,d}(x,Q^2)dx$$



scaling: $\ln Q^2$

higher twist: $(1/Q^2)^n$
target mass corrections

dominating resonances

χPT: $(Q^2)^n$

Jefferson Lab @ 6 GeV explores the transition from DIS to χPT

Higher Twist in Moments

CLAS data make moments possible

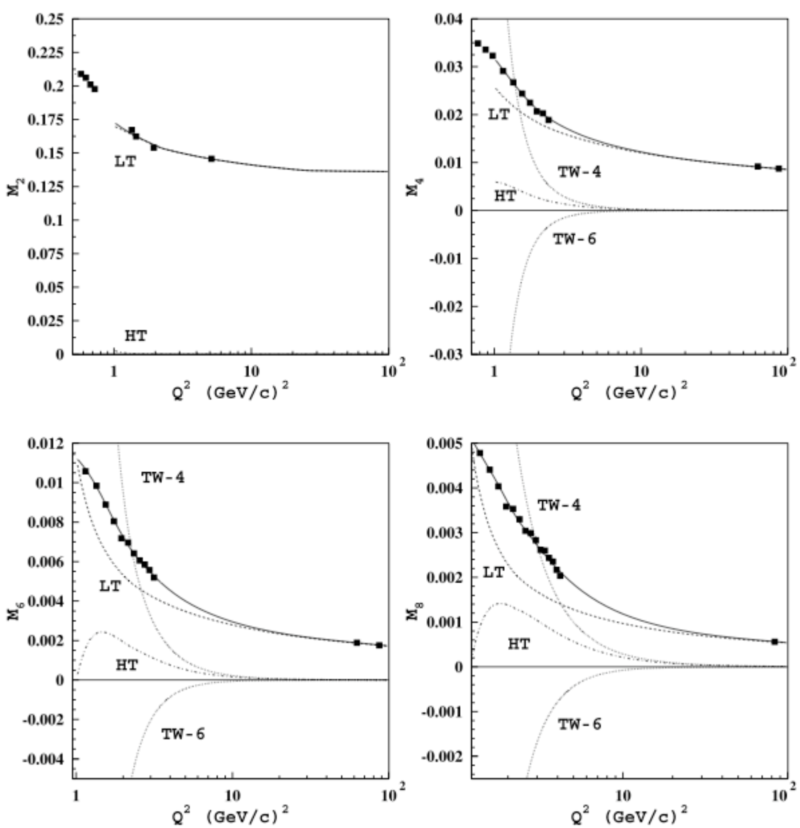
$$M_1(Q^2) = \int_0^1 dx\, \frac{\xi^2}{x^2}\left\{ g_1(x, Q^2)\left(\frac{x}{\xi} - \frac{1}{9}\frac{M^2 x\xi}{Q^2}\right) - g_2(x, Q^2)\frac{4}{3}\frac{M^2x^2}{Q^2}\right\},$$

$$\xi = 2x/(1 + \sqrt{1 + 4M^2x^2/Q^2})$$

Osipenko et al, NPA845(10)1

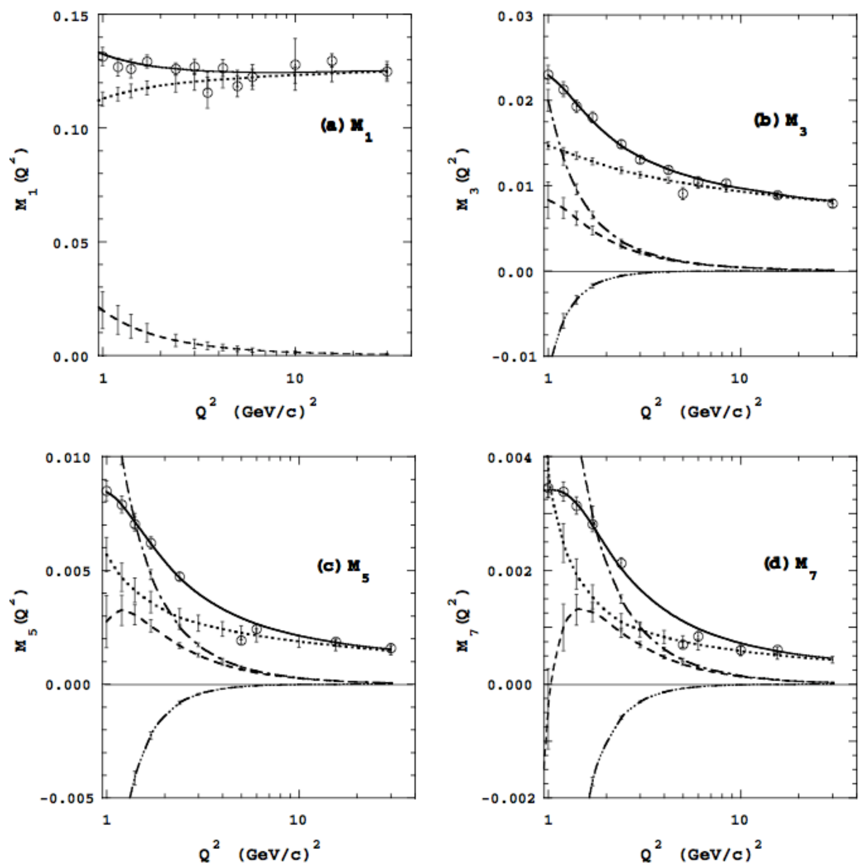
Nachtmann moments for ^{12}C

M. Osipenko et al. / Nuclear Physics A 845 (2010) 1–32 23



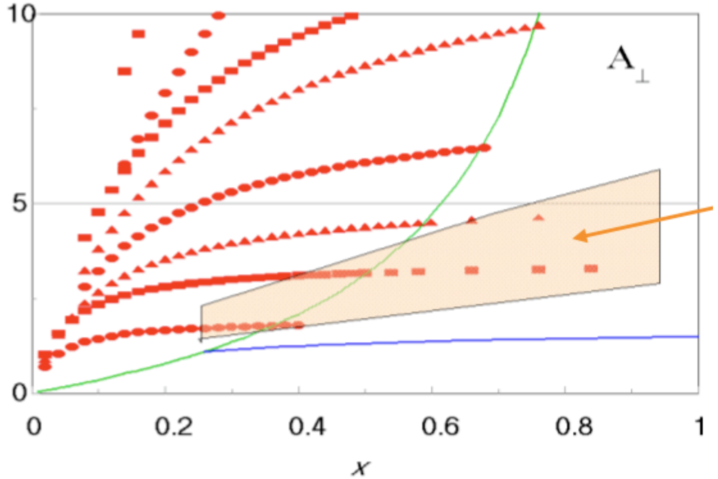
Osipenko et al, PRD71(05)054007

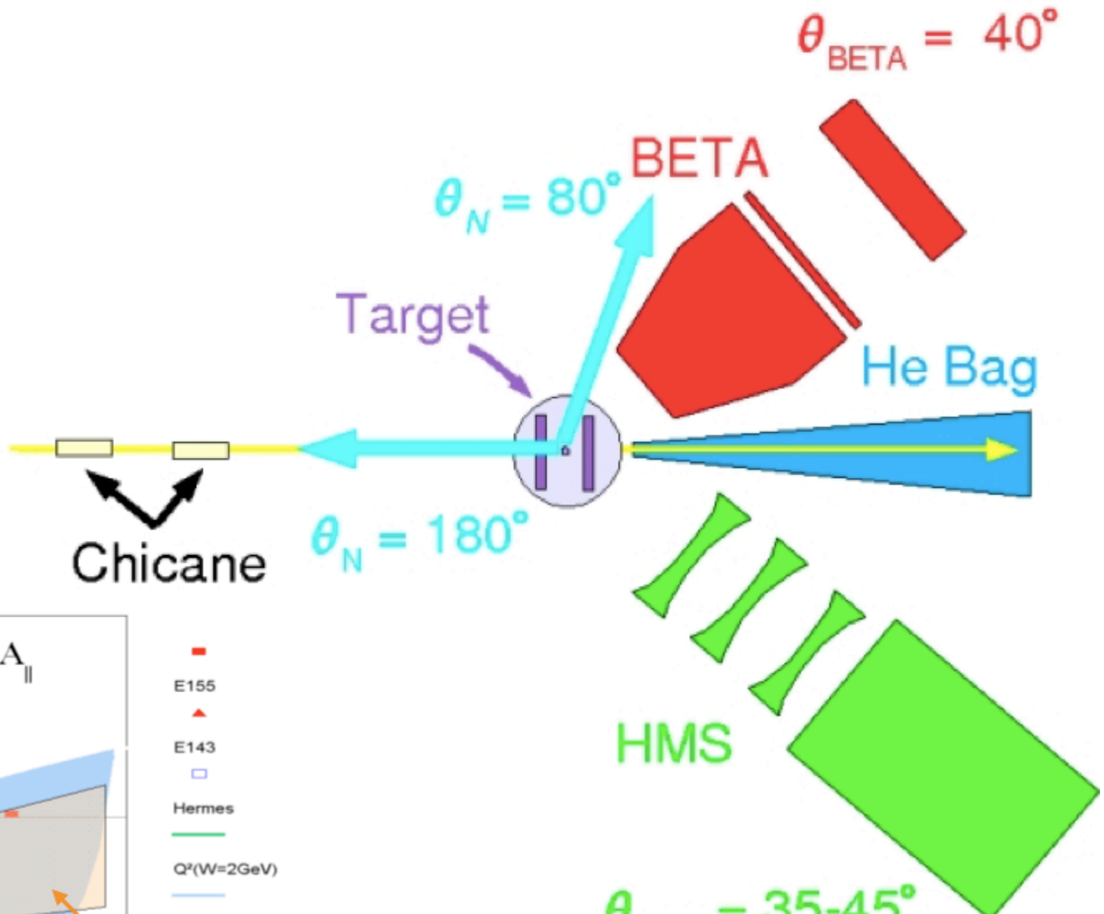
Polarized Nachtmann moments

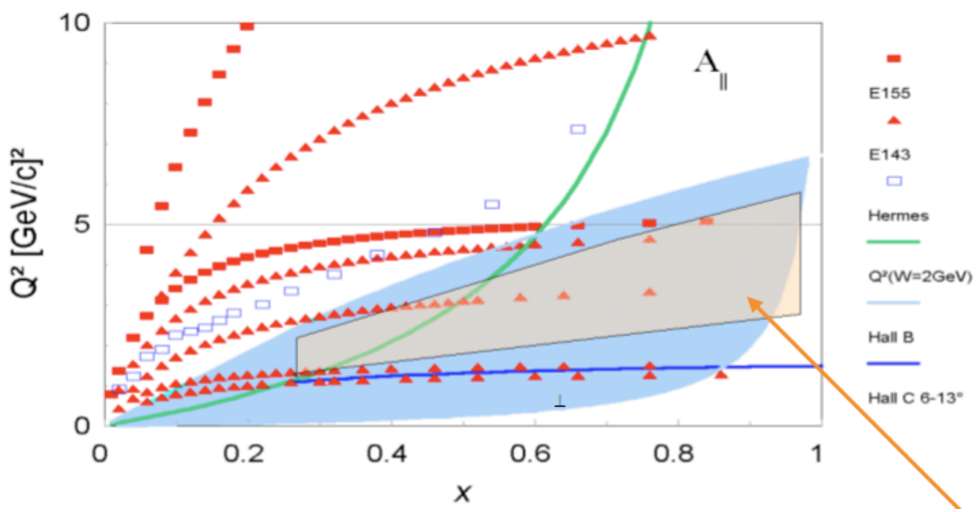


Hall C SANE

★**WG6PSH1: Hovhannes Baghdasaryan** ***Preliminary proton spin asymmetry results from SANE***







Hall C SANE

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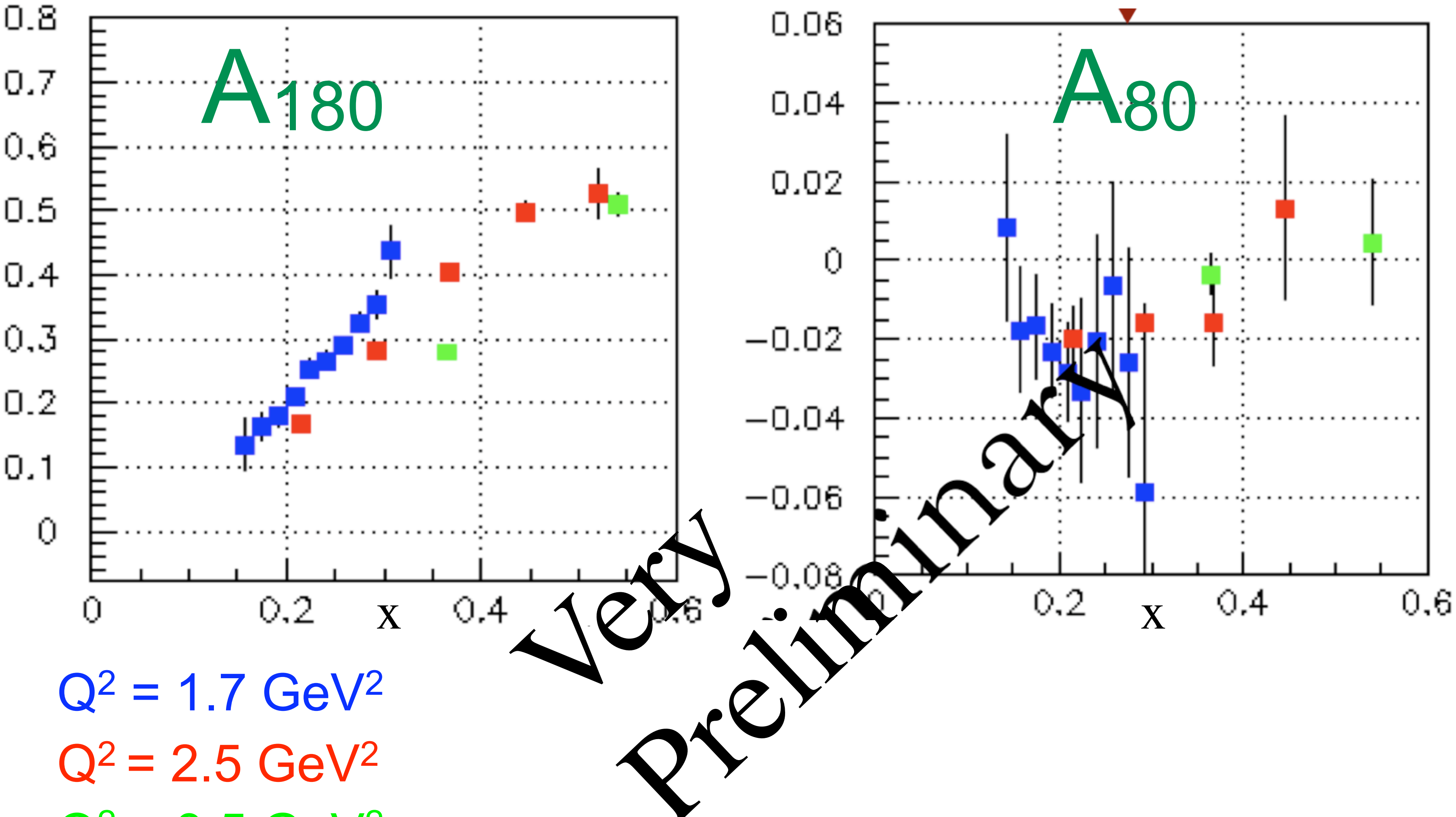


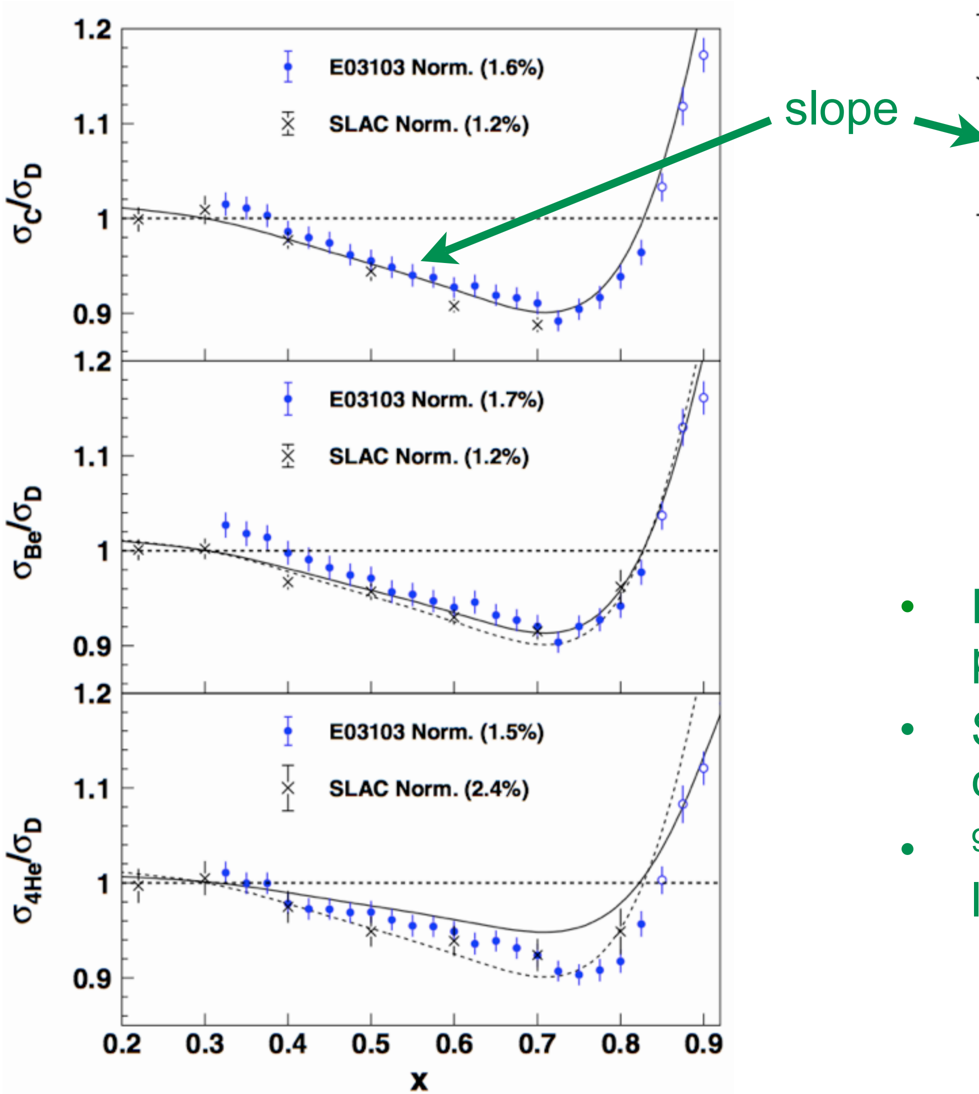
Q^2 = 1.7 GeV^2

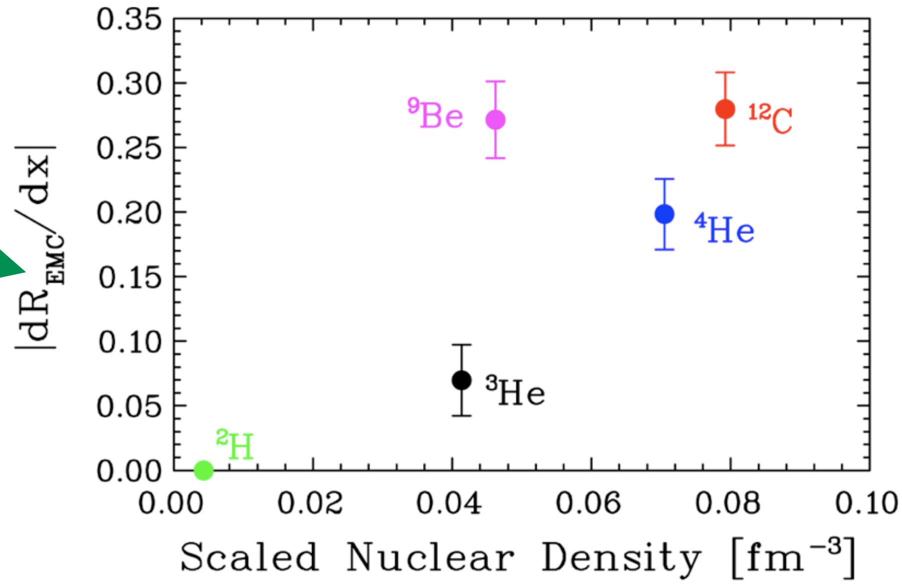
Q^2 = 2.5 GeV^2

Q^2 = 3.5 GeV^2

Hall C EMC Effect

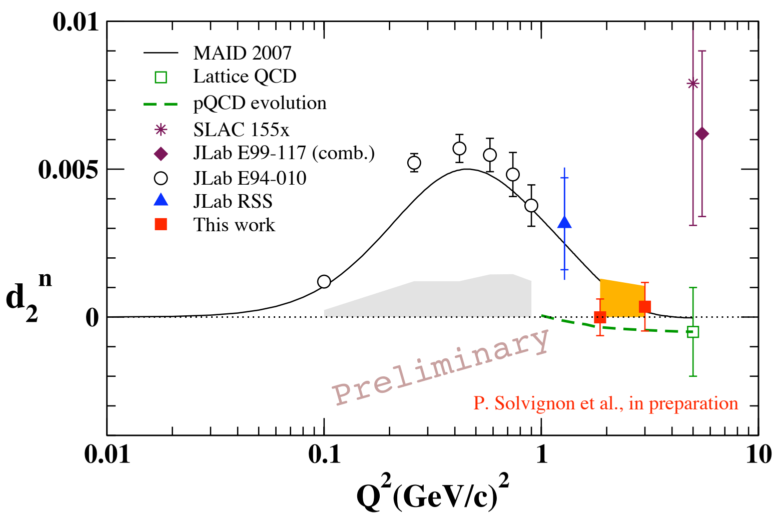
Seely et al, PRL103(09)202301





- Recent data from JLab are very precise.
- Slope with respect to x is used to characterize the strength of the effect
- ^{9}Be anomaly is used to argue for a local-density origin of the effect

Hall A g_2^n



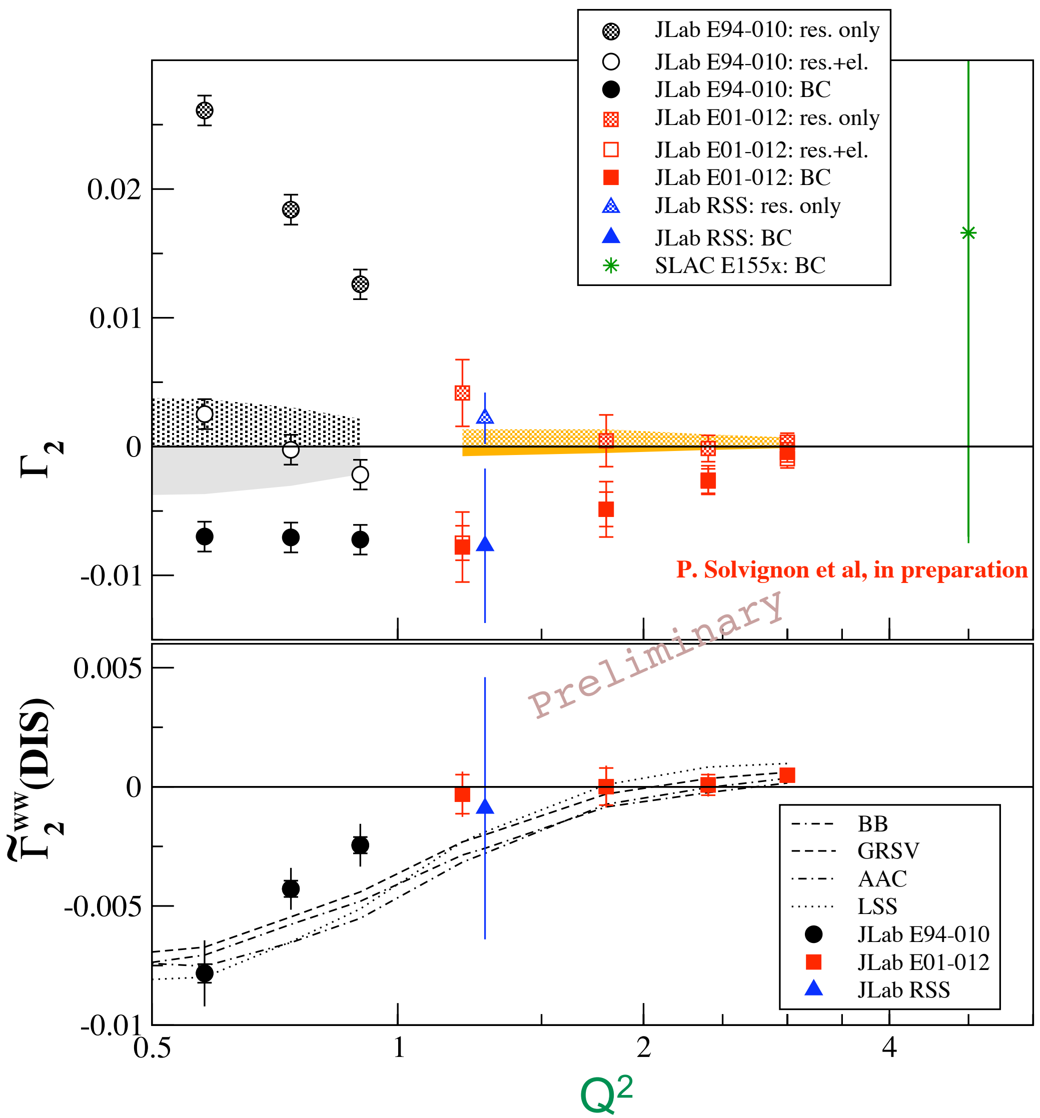
- higher twist coefficient

$$d_2(Q^2) = \int_0^1 dx\, x^2[2g_1(x,Q^2) + 3g_2(x,Q^2)]$$

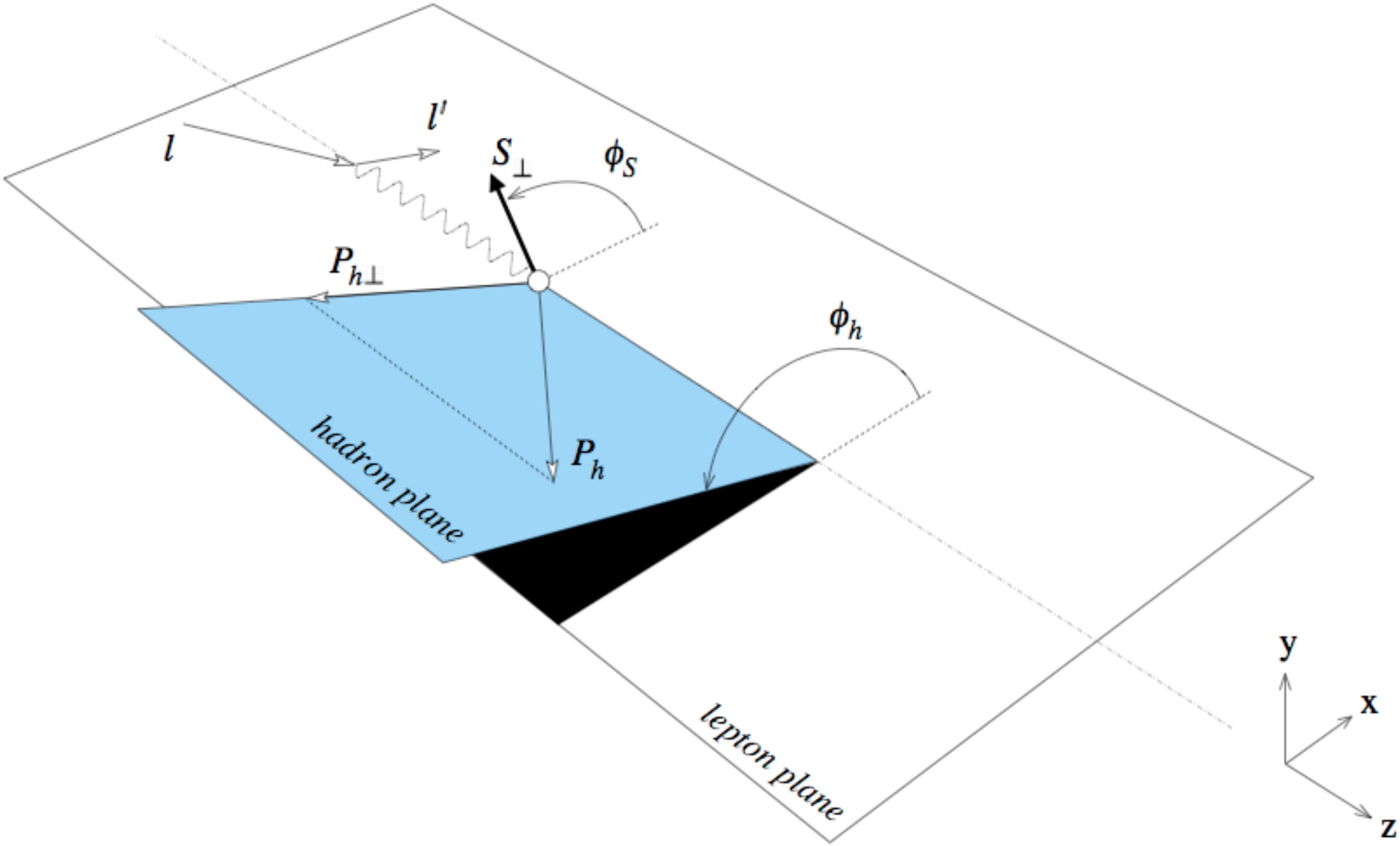
- Burkhardt-Cottingham Sum Rule

$$\int_0^1 g_2(x,Q^2)dx = 0$$

- Γ_2^{WW} is sum of g_2^{WW} for W>2 GeV



Semi-Inclusive DIS



Differential Cross Section

Bacchetta, et al., JHEP 2(2007)093

Unpolarized and Longitudinally polarized

$$\frac{d\sigma}{dx\,dy\,d\psi\,dz\,d\phi_h\,dP_{h\perp}^2} =$$

$$\frac{\alpha^2}{xyQ^2}\,\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Bigg\{\boxed{F_{UU,T}} + \varepsilon\,\overset{0}{F_{UU,L}} + \sqrt{2\,\varepsilon(1+\varepsilon)}\,\cos\phi_h\,F_{UU}^{\cos\phi_h}$$

$$+\,\varepsilon\cos(2\phi_h)\,F_{UU}^{\cos 2\phi_h} + \lambda_e\,\sqrt{2\,\varepsilon(1-\varepsilon)}\,\sin\phi_h\,F_{LU}^{\sin\phi_h}$$

$$+\,S_\parallel\left[\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_h\,\boxed{F_{UL}^{\sin\phi_h}} + \varepsilon\sin(2\phi_h)\,\boxed{F_{UL}^{\sin 2\phi_h}}\right]$$

$$+\,S_\parallel\lambda_e\left[\sqrt{1-\varepsilon^2}\,\boxed{F_{LL}} + \sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_h\,F_{LL}^{\cos\phi_h}\right]\Bigg\}$$

A_{UL} = {UL terms} / {UU terms}

A_{LL} = {LL terms} / {UU terms}

↖ = Higher Twist

Differential Cross Section

Bacchetta, et al., JHEP 2(2007)093

Transverse target polarizations

0 at high Q^2

= Higher Twist

$$\frac{d\sigma}{dx\,dy\,d\psi\,dz\,d\phi_h\,dP_{h\perp}^2} =$$

$$\frac{\alpha^2}{xyQ^2}\,\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Bigg\{$$

$$+\,|\boldsymbol{S}_\perp|\Bigg[\sin(\phi_h-\phi_S)\left(\boxed{F_{UT,T}^{\sin(\phi_h-\phi_S)}}+\varepsilon\,F_{UT,L}^{\sin(\phi_h-\phi_S)}\right)$$

$$+\,\varepsilon\,\sin(\phi_h+\phi_S)\,\boxed{F_{UT}^{\sin(\phi_h+\phi_S)}}+\varepsilon\,\sin(3\phi_h-\phi_S)\,F_{UT}^{\sin(3\phi_h-\phi_S)}$$

$$+\,\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin\phi_S\,F_{UT}^{\sin\phi_S}+\sqrt{2\,\varepsilon(1+\varepsilon)}\,\sin(2\phi_h-\phi_S)\,F_{UT}^{\sin(2\phi_h-\phi_S)}\Bigg]$$

$$+\,|\boldsymbol{S}_\perp|\lambda_e\Bigg[\sqrt{1-\varepsilon^2}\,\cos(\phi_h-\phi_S)\,F_{LT}^{\cos(\phi_h-\phi_S)}+\sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos\phi_S\,F_{LT}^{\cos\phi_S}$$

$$+\,\sqrt{2\,\varepsilon(1-\varepsilon)}\,\cos(2\phi_h-\phi_S)\,F_{LT}^{\cos(2\phi_h-\phi_S)}\Bigg]\Bigg\},$$

TMDs and Fragmentation

The observables are the structure functions such as $F^{\sin\phi}_{UL}$, not the transverse momentum distributions (TMDs) or fragmentation functions (FFs). Four-fold differential data in x, z, Q^2 and P_T are essential to allow modeling of TMDs and FFs.

$$\mathcal{C}\big[w\, f\, D\big] = x \sum_a e_a^2 \int d^2\boldsymbol{p}_T\, d^2\boldsymbol{k}_T\, \delta^{(2)}\big(\boldsymbol{p}_T - \boldsymbol{k}_T - \boldsymbol{P}_{h\perp}/z\big)\, w(\boldsymbol{p}_T, \boldsymbol{k}_T)\, f^a(x, p_T^2)\, D^a(z, k_T^2),$$

$$F_{UL}^{\sin\phi_h} = \frac{2M}{Q}\, \mathcal{C}\left[-\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_T}{M_h}\left(x h_L H_1^\perp + \frac{M_h}{M}\, g_{1L}\frac{\tilde{G}^\perp}{z}\right) + \frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{p}_T}{M}\left(x f_L^\perp D_1 - \frac{M_h}{M}\, h_{1L}^\perp \frac{\tilde{H}}{z}\right)\right]$$

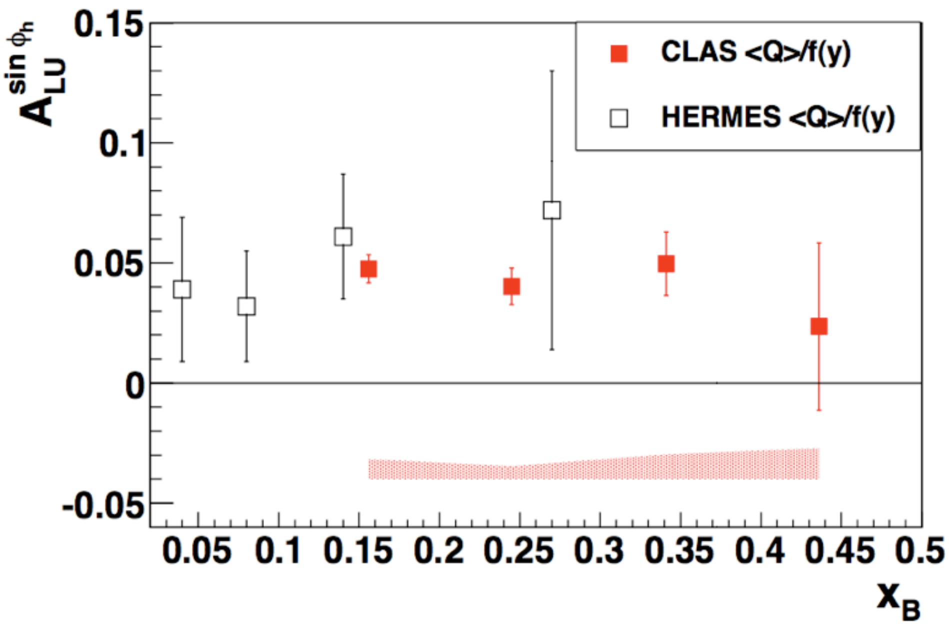
$$F_{UL}^{\sin 2\phi_h} = \mathcal{C}\left[-\frac{2\,(\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_T)\,(\hat{\boldsymbol{h}}\cdot\boldsymbol{p}_T) - \boldsymbol{k}_T\cdot\boldsymbol{p}_T}{M M_h}\, h_{1L}^\perp H_1^\perp\right],$$

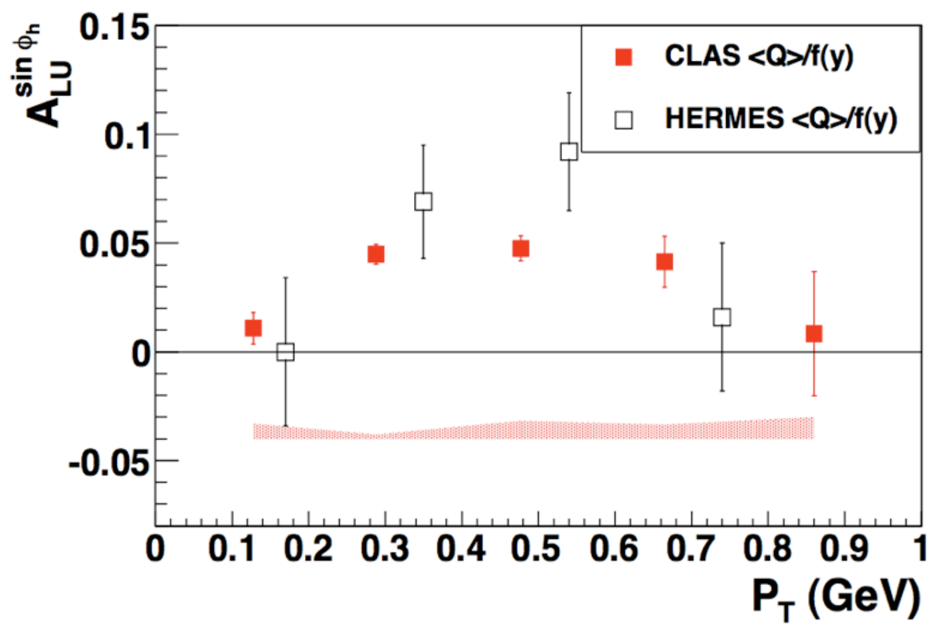
$$F_{LL} = \mathcal{C}\big[g_{1L} D_1\big]$$

$$F_{LL}^{\cos\phi_h} = \frac{2M}{Q}\, \mathcal{C}\left[\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_T}{M_h}\left(x e_L H_1^\perp - \frac{M_h}{M}\, g_{1L}\frac{\tilde{D}^\perp}{z}\right) - \frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{p}_T}{M}\left(x g_L^\perp D_1 + \frac{M_h}{M}\, h_{1L}^\perp \frac{\tilde{E}}{z}\right)\right]$$

CLAS A_{LU}

- Mher Aghasyan et al., E01-113 in preparation for publication
- CLAS data for $A_{UL}^{\pi^\circ}$
- Unpolarized liquid hydrogen target
- Beam energy of 5.776 GeV
- $Q^2>1$; $0.4 < z < 0.7$





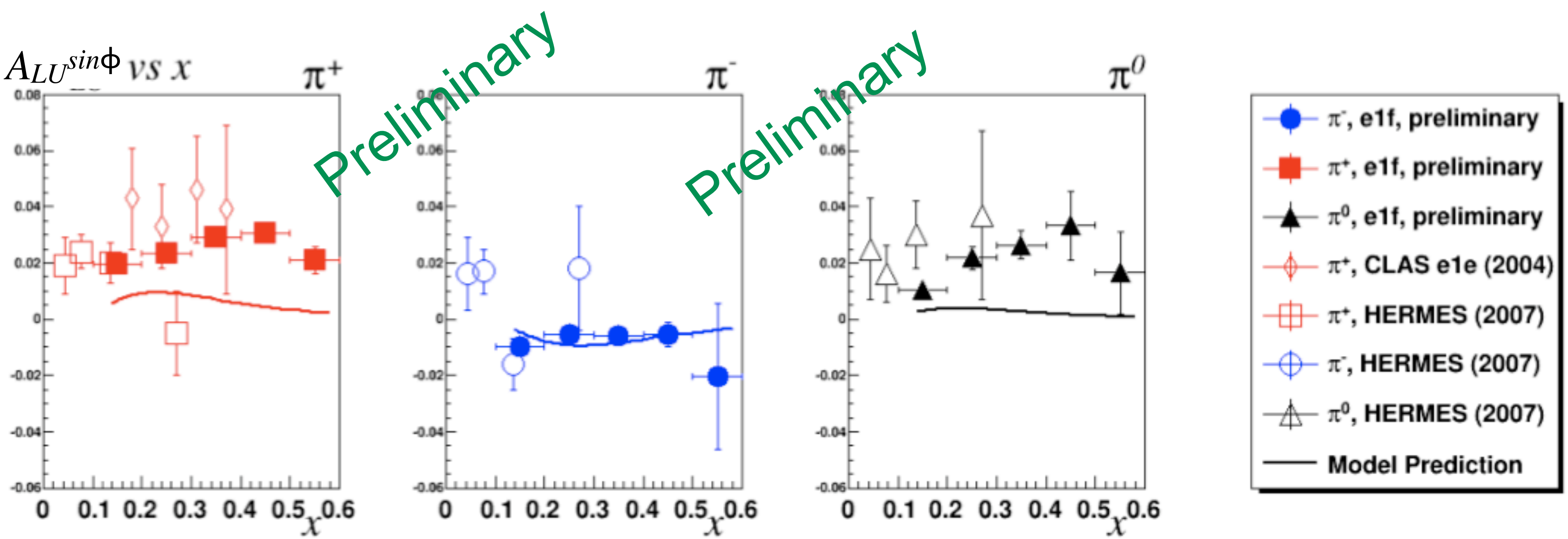
CLAS A_{LU}

★**WG6PST3: Wes Gohn *Beam single spin asymmetries in SIDIS from an unpolarized proton***

- CLAS data from E1f run period (2003)
- Unpolarized liquid hydrogen target
- Longitudinal beam polarization of 75%
- Beam energy of 5.498 GeV

CLAS, Avakian et al, PRC69(04)042201

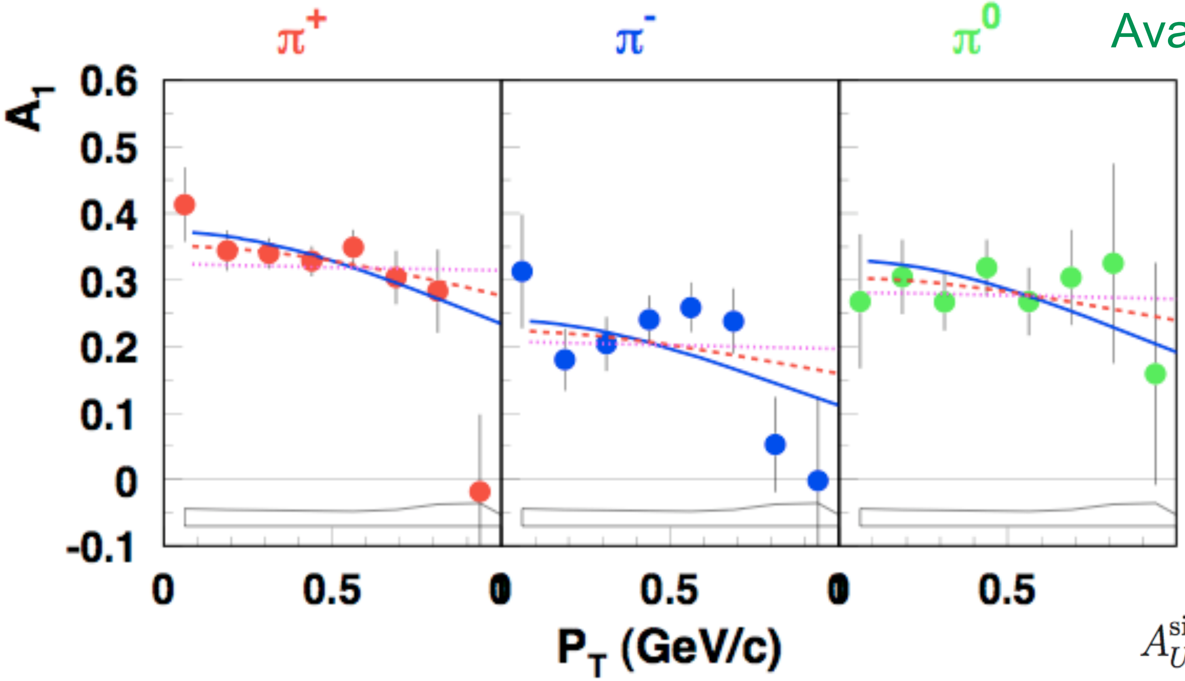
HERMES, Airapetian et al, PLB648(07)164



The College of WILLIAM & MARY

Asymmetries from eg1b

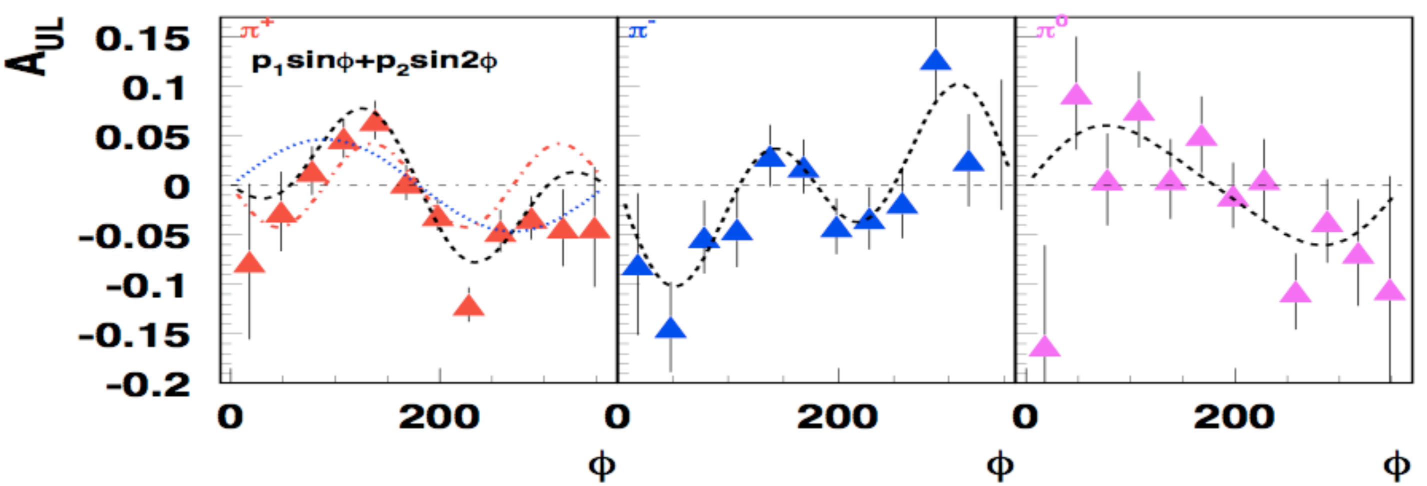
Avakian et al., PRL105(10)262002



$$A_1 \equiv \frac{F_{LL}}{F_{UU,T}}$$

CLAS

$$A_{UL}^{\sin 2\phi}(x) = \frac{\int dy\, [\cos\theta_\gamma(1-y)/Q^4] F_{UL}^{\sin 2\phi}}{\int dy\, [(1-y+\frac{1}{2}y^2)/Q^4] F_{UU,T}}$$



$A_1 \approx g_1/F_1$ for eg1-dvcs

★WG6PST3: Sucheta Jawalkar *Spin azimuthal asymmetries on longitudinally polarized proton*

$$f_1^q(x,k_T) = f_1(x)\frac{1}{\pi\mu_0^2}\exp\left(-\frac{k_T^2}{\mu_0^2}\right)$$

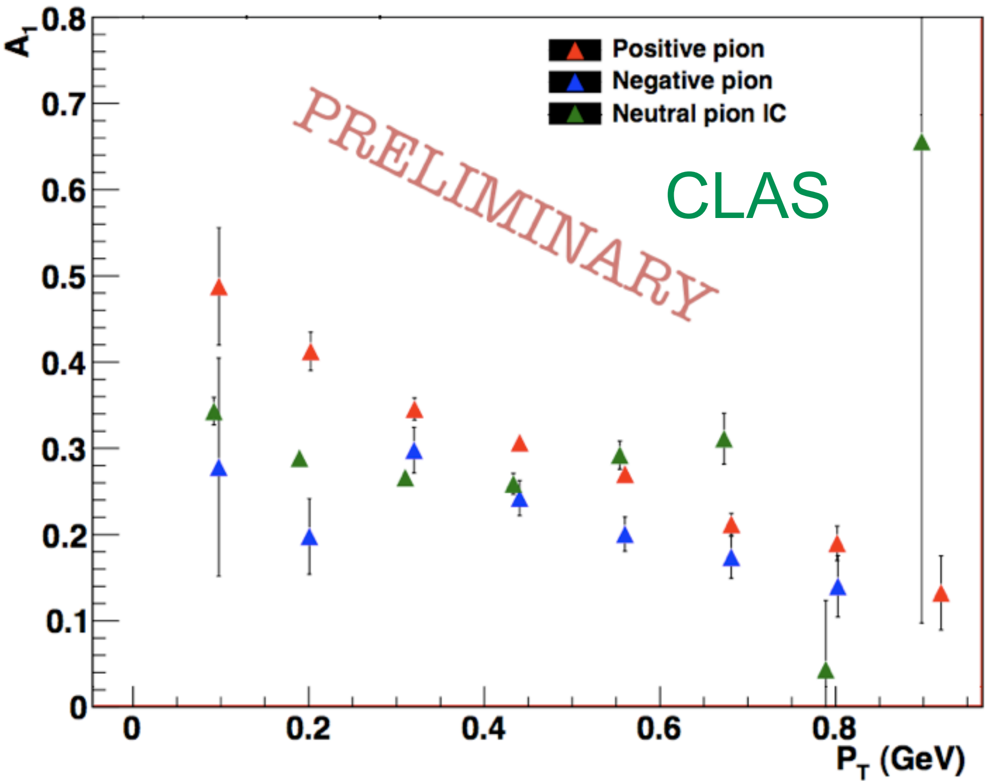
$$g_1^q(x,k_T) = g_1(x)\frac{1}{\pi\mu_2^2}\exp\left(-\frac{k_T^2}{\mu_2^2}\right)$$

$$D_1^q(z,p_T) = D_1(z)\frac{1}{\pi\mu_D^2}\exp\left(-\frac{p_T^2}{\mu_D^2}\right),$$

$$\frac{g_1}{F_1} \propto \frac{\sum_q e_q^2 g_1^q(x) D_1^{q\to\pi}(z)}{\sum_q e_q^2 f_1^q(x) D_1^{q\to\pi}(z)} e^{-z^2 P_T^2 \frac{(\mu_0^2-\mu_2^2)}{(\mu_D^2+z^2\mu_0^2)(\mu_D^2+z^2\mu_2^2)}}$$

- eg1-dvcs data (25%) of total
- P_T dependence → $\mu_0 \neq \mu_2$
- For π^+, π^- and π^0

CLAS



A_{UL} for eg1-dvcs

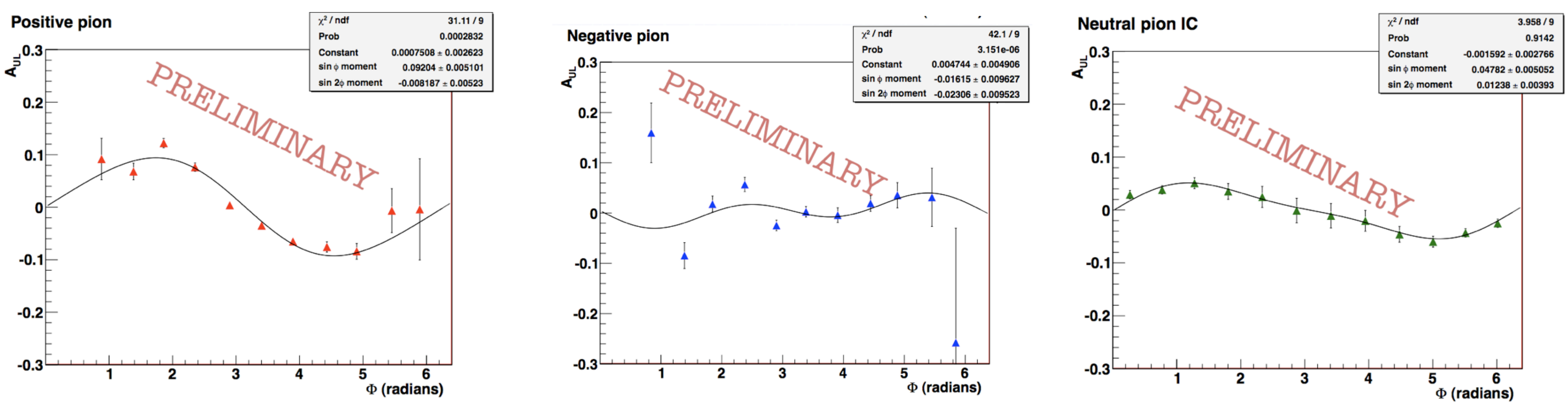
★**WG6PST3: Sucheta Jawalkar** ***Spin azimuthal asymmetries on longitudinally polarized proton***

The target spin asymmetries as a function of ϕ have both $\sin\phi$ and $\sin2\phi$ components.

$A^{\sin\phi}_{UL}$ (higher twist) is significant for π^+, π^0

$A^{\sin2\phi}_{UL}$ (leading twist) is small suggesting, like for eg1b and HERMES, that the Collins favored and unfavored fragmentation functions are nearly equal and opposite.

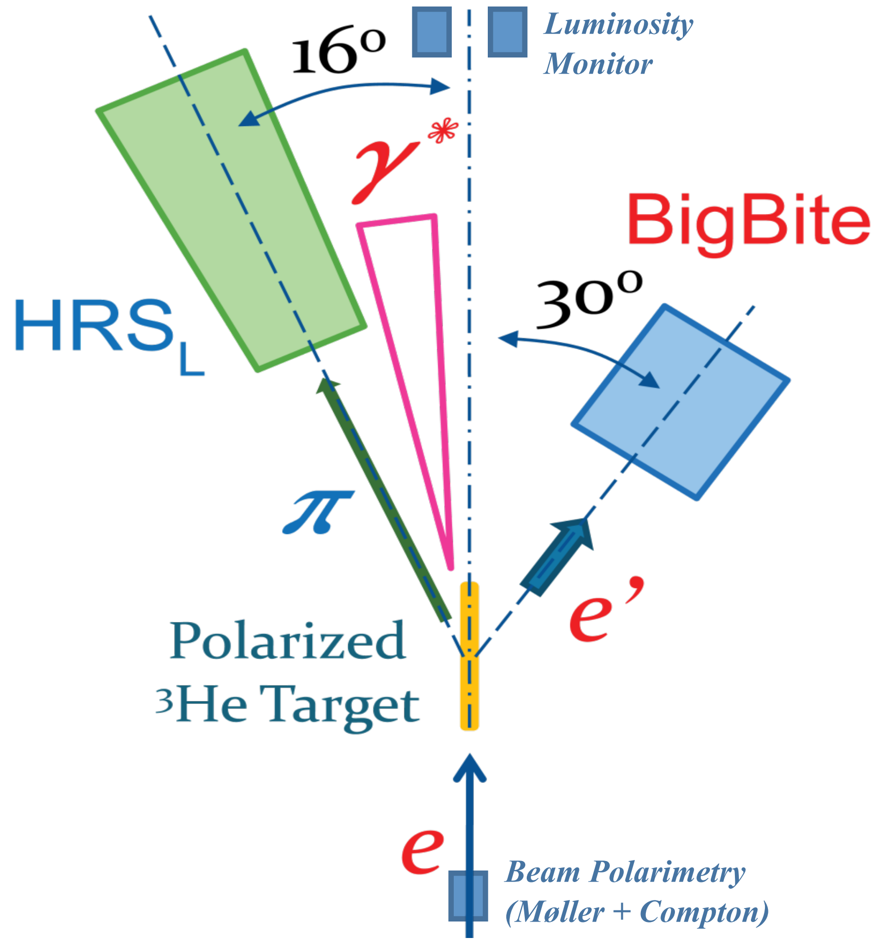
CLAS



E06-010: Transversity

Spokesepersons: J. P. Chen, E. Cisbani, H. Gao, X. Jiang, J. C. Peng

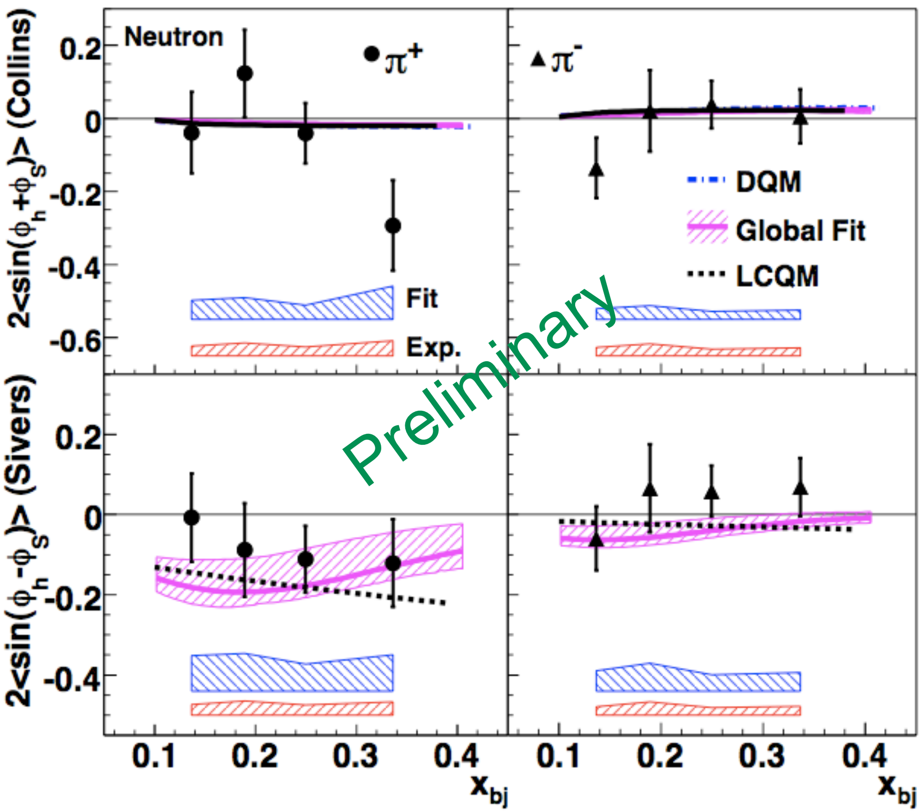
- First measurement on n
- Polarized ^{3}He target



Hall A E06-010 A_{UT}

★**WG6PST4: Kalyan Allada *Single spin asymmetry results from neutron***

X. Qian, et al., in preparation



$$2 < \cos(\phi_h + \phi_s) > \propto h_{1T}^q \otimes H_{1q}^h$$

$$2 < \cos(\phi_h - \phi_s) > \propto f_{1T}^q \otimes D_{1q}^h$$

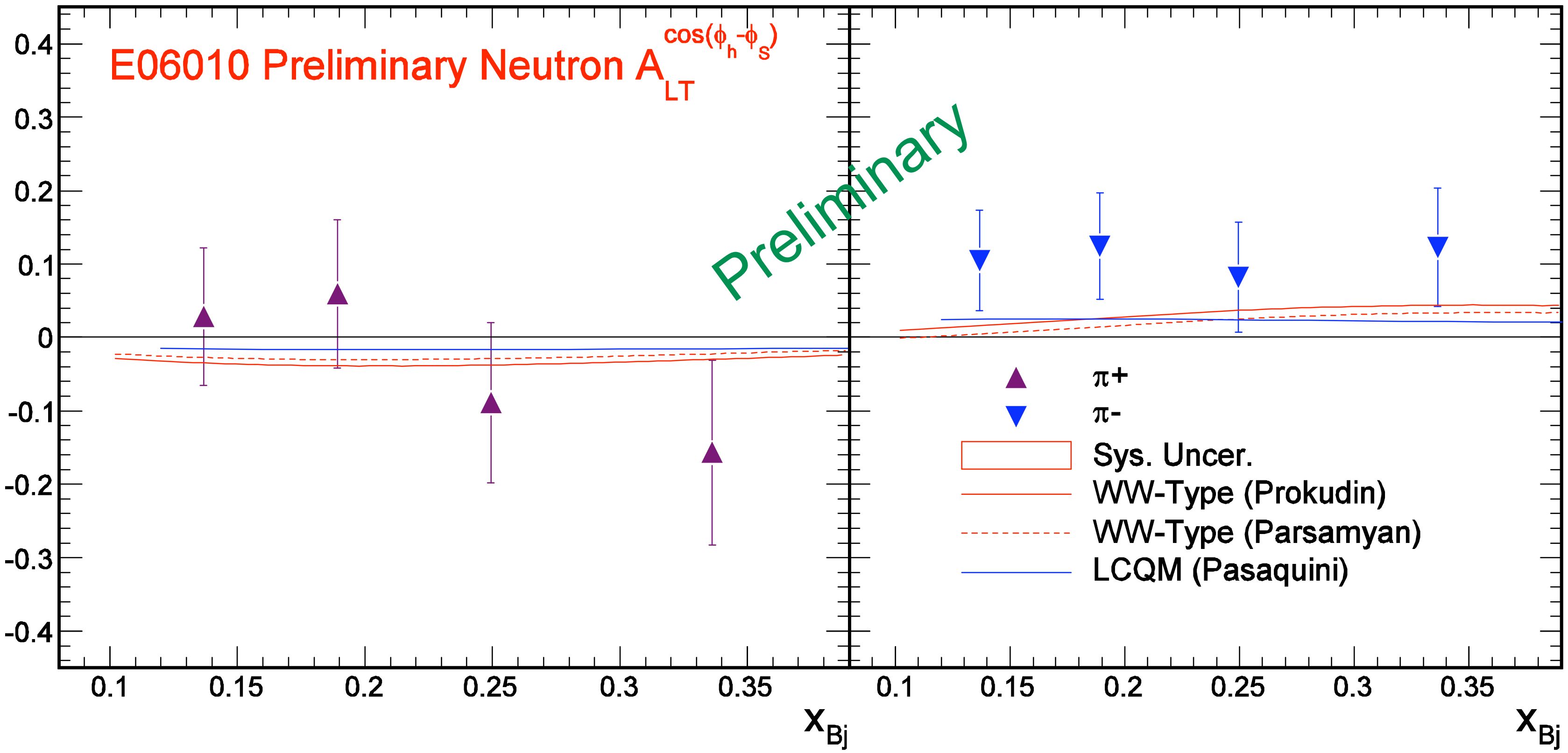
A_{UT}

- Preliminary Collins/Sivers for n
- 5.9 GeV electron beam
- Polarized ^{3}He target
- $0.14 < x < 0.35$
- $1.3 < Q^2 < 2.7$ GeV^2
- Still working on systematic uncertainties
- Curves: diquark model (Ma), global fit (Anselmino), light-cone quark model (Pasquini)

Hall A A_{LT} for the Neutron

★**WG6PST2: Jin Huang** ***Measurement of double spin asymmetry A_{LT}***

At leading twist: $A_{LT}^{\cos(\phi_h - \phi_s)} \propto g_{1T}^q \otimes D_{1q}^h$



DIS Lambda Production

★WG6PSTV: Marco Mirazita *Lambda polarization in electroproduction at CLAS*

$$P_\Lambda^{measured} = P_\Lambda^0 + P_\Lambda^{\cos\phi}\langle\cos(\phi)\rangle \approx P_\Lambda^0 - 0.85 P_\Lambda^{\cos\phi}$$

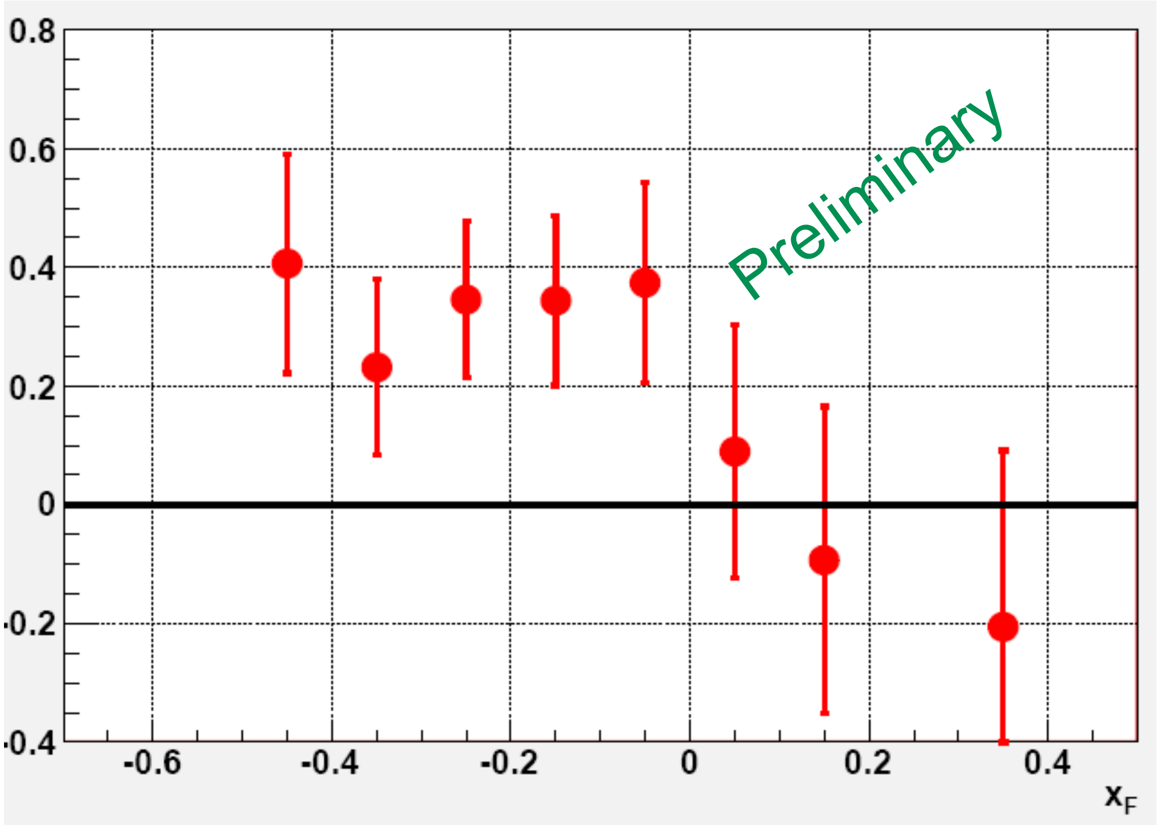
$x_F < 0$

$P_\Lambda^{\text{measured}} \sim 0.3$

$$\Rightarrow P_\Lambda^0 \neq P_\Lambda^{\cos\phi}$$

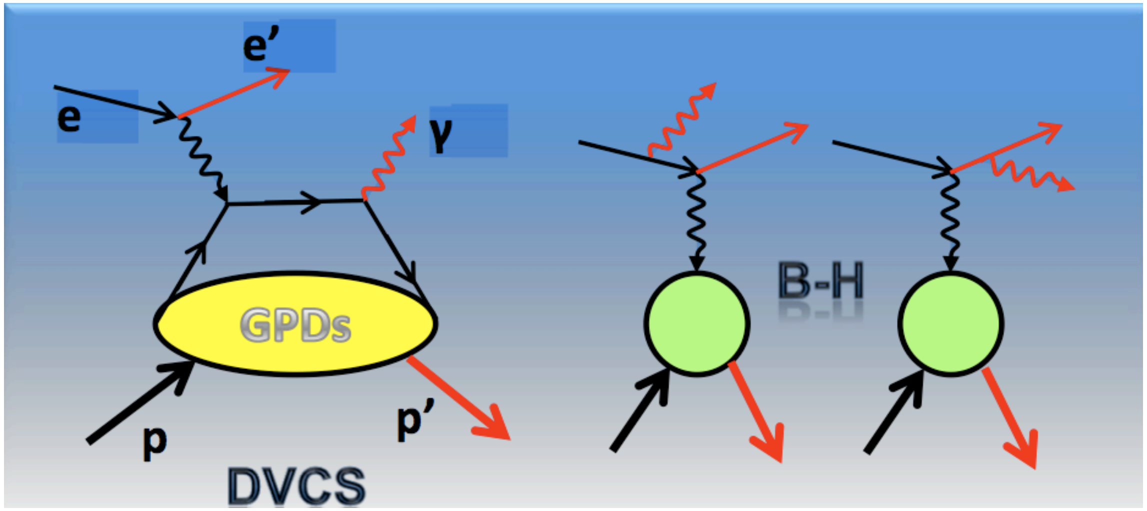
$x_F > 0$

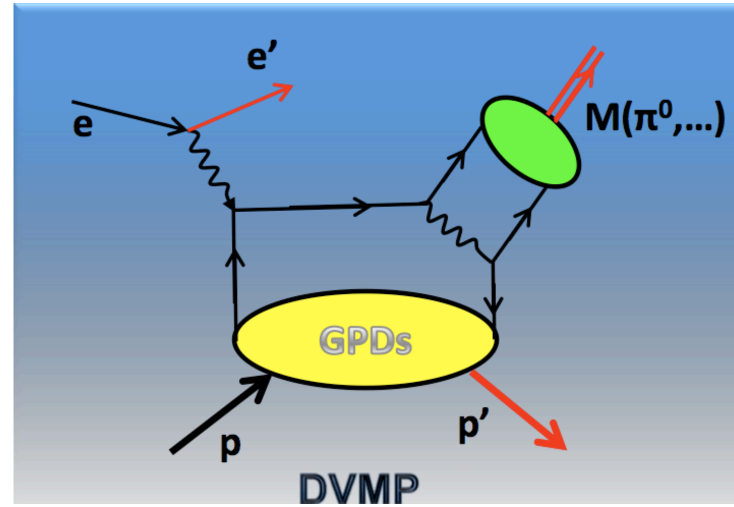
$P_\Lambda^{\text{measured}} \sim 0.$



DVCS and DVMP

★WG2PSVM: Valery Kubarovsky *Vector-mesons production and DVCS at JLab*





$$\frac{d^4\sigma}{dQ^2 dx_B dt d\phi} \sim |T^{DVCS} + T^{BH}|^2$$

$$A_{LU} \sim \Im m\left\{F_1\mathcal{H} + \xi(F_1+F_2)\tilde{\mathcal{H}} - \frac{\Delta^2}{4M^2}F_2\mathcal{E}\right\}\sin\phi$$

suppressed

$$A_{UL} = \Im m\left\{F_1\tilde{\mathcal{H}} + \xi(F_1+F_2)\left(\mathcal{H} - \frac{x_B}{2}\mathcal{E}\right) - \xi\left(\frac{x_B}{2}F_1 + \frac{\Delta^2}{4M^2}F_2\right)\tilde{\mathcal{E}}\right\}\sin\phi$$

sinϕ moments of A_{LU} and A_{UL} are related to linear combinations of generalized parton distributions

$$A = \alpha\sin\phi + \beta\sin 2\phi$$

higher twist

ρ^0 DVMP @ CLAS

Morrow et al, EPJA39(09)5

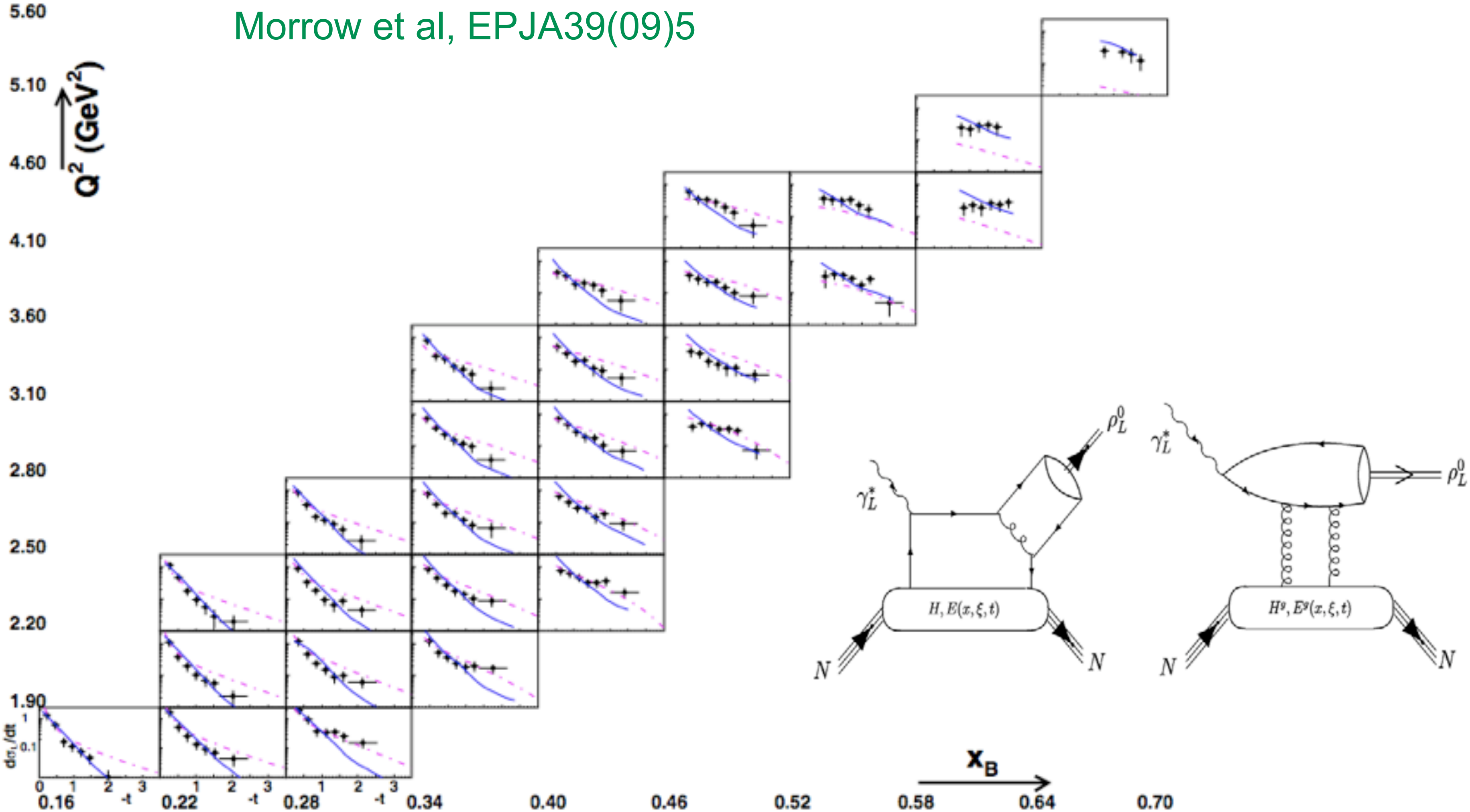


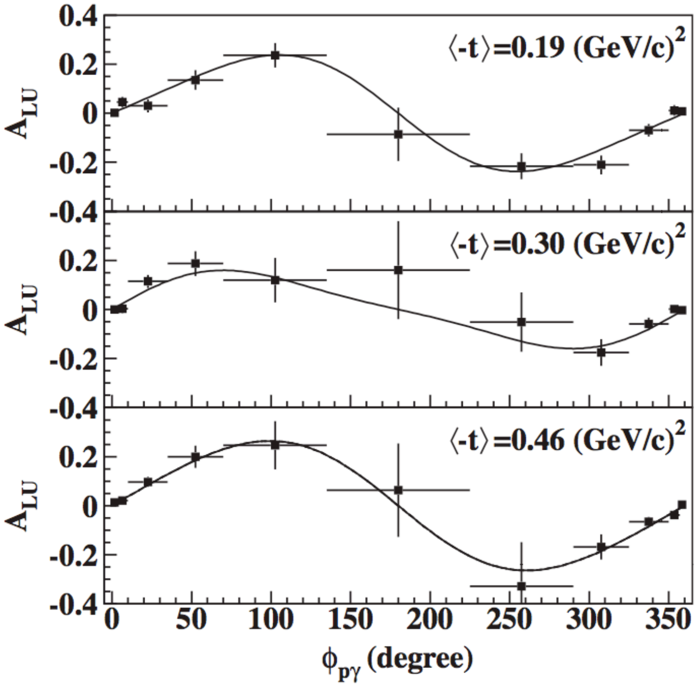
Fig. 26. Longitudinal cross-section $d\sigma_L/dt$ (in μb/GeV^2) for all bins in (Q^2, x_B) as a function of t (in GeV^2). The thick solid curve represents the result of the VGG calculation with the addition of the generalized D-term. The dash-dotted curve is the result of the JML model.

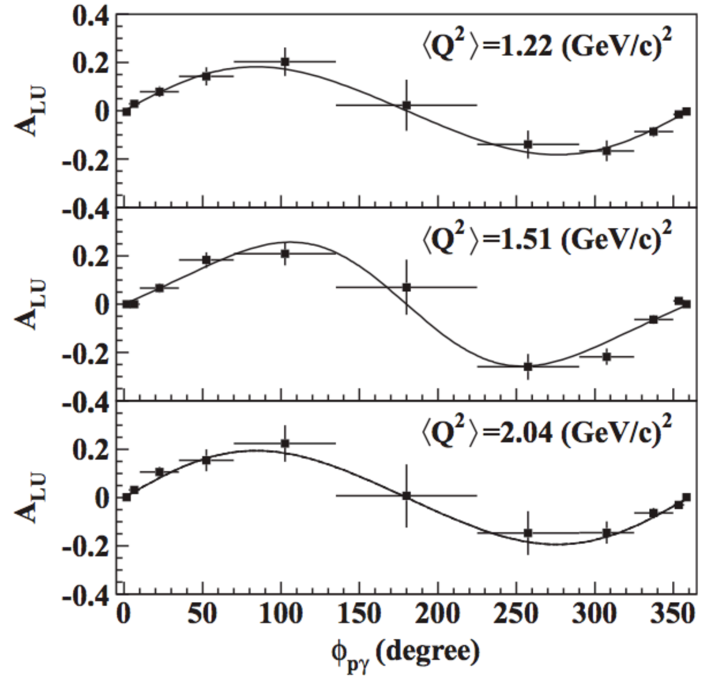
CLAS DVCS A_{LU}

G. GAVALIAN *et al.* $$A = \alpha \sin\phi + \beta \sin 2\phi$$ PHYSICAL REVIEW C **80**, 035206 (2009)

TABLE III. Results from the fits to the ϕ dependences of A_{LU} with the functions presented in Eqs. (19) and (22). Only statistical uncertainties are presented.

$\langle Q^2\rangle$ [(GeV/c)^2]	$\langle x_B\rangle$	$\langle -t\rangle$ [(GeV/c)^2]	α	β	α'	γ
1.22	0.17	0.23	0.181 ± 0.032	0.099 ± 0.023	0.181 ± 0.032	-0.098 ± 0.228
1.51	0.20	0.26	0.245 ± 0.028	-0.040 ± 0.021	0.234 ± 0.024	0.319 ± 0.195
2.04	0.28	0.38	0.192 ± 0.044	0.010 ± 0.030	0.191 ± 0.045	-0.107 ± 0.288



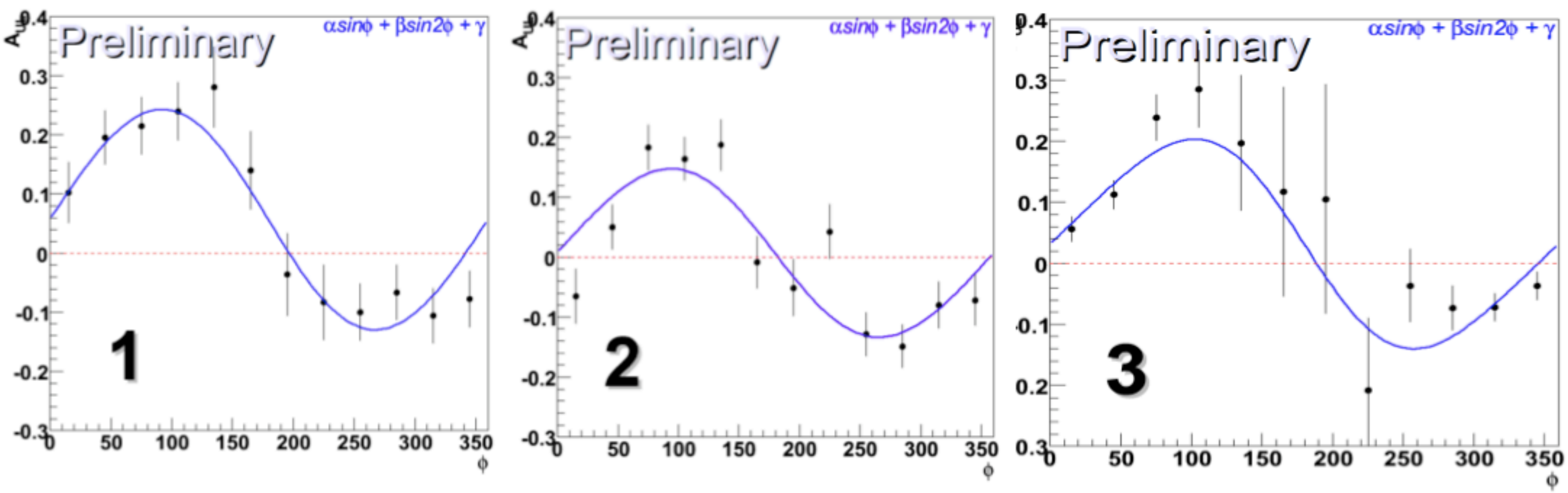


DVCS Target SSA

★**WG6PSHP1: Andrey Kim** ***Studies of exclusive processes with a longitudinally polarized target***

$$A = \alpha \sin\phi + \beta \sin 2\phi$$

CLAS
eg1-dvcs data



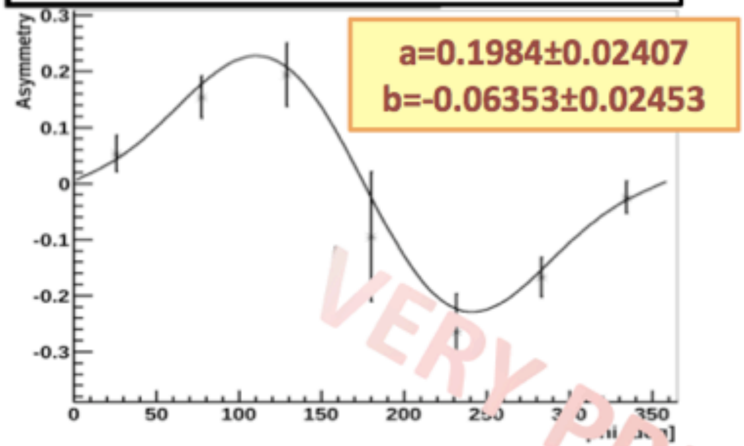
DVMP Target SSA

★**WG6PSHP1: Andrey Kim** ***Studies of exclusive processes with a longitudinally polarized target***

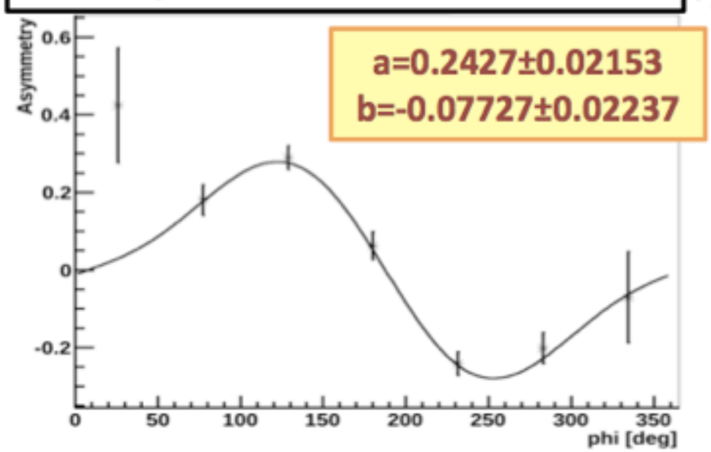
CLAS neutral pions

$A = a \cdot \sin\phi + b \cdot \sin 2\phi$

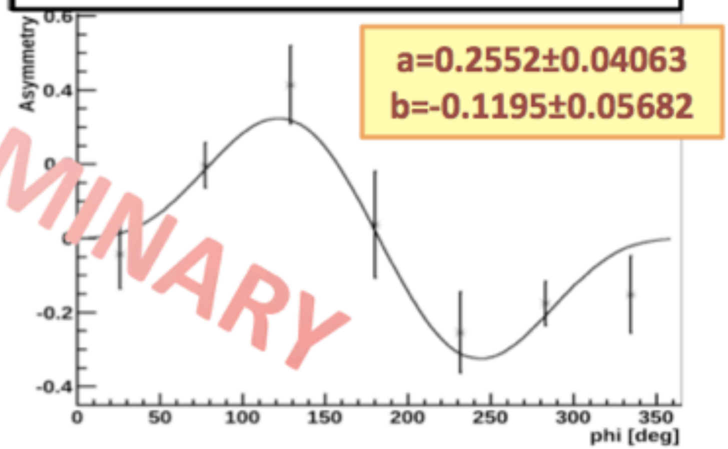
✓**Both photons in IC:**



✓**Both photons in EC:**



✓**One photon in EC, second in IC:**



Conclusions

- Jefferson Lab has an intense program on:
  - unpolarized and polarized inclusive DIS
  - semi-inclusive DIS with pions
  - DVCS
  - DVMS with pions and rhos
  - using proton, deuteron, ^{3}He, and nuclear targets
- Details of these topics can be found:
  - in the advertised talks at DIS2011